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A COMPARATIVE ANALYSIS OF SHIP OPERATIONAL TEST AND EVALUATION IN THE UNITED STATES NAVY AND THE ROYAL AUSTRALIAN NAVY

by

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IN THE UNITED STATES NAVY AND THE ROYAL AUSTRALIAN NAVY

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ABSTRACT

This thesis provides a comparative analysis of ship Operational Test and Evaluation (OT&E) in the United States Navy (USN) and the Royal Australian Navy (RAN). It also reviews the acceptance and introduction into service procedures for warships in both Navies, including the input from OT&E. This study analyses USN and RAN Ship OT&E organisation, policy, and procedures, and then compares and contrasts the two systems. The study finds that the RAN OT&E system, although originally based on USN OT&E philosophy, now differs in the importance, interpretation, application and focus of OT&E. It concludes that to achieve efficient and effective trials and acceptance of the new higher risk warships currently under construction, the RAN OT&E system needs to be revised. A model for OT&E in the RAN is proposed based on the principles derived from the USN system. The recommendations include the initial conduct of OT&E in land based test sites, followed by dedicated "Whole Ship" OT&E for the first of class.

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EXECUTIVE SUMMARY

With new frigates and submarines under construction, the Royal Australian Navy (RAN) has embarked on its greatest combatant shipbuilding program since the Second World War. Although these combatants are being built to proven designs and, therefore, are considered relatively low risk, they do present a greater operational risk than recent RAN combatant programs. In September 1991, the Chief of Naval Staff (CNS) expressed concern that the RAN may not be capable of adequately managing the comprehensive and complex procedures necessary to accept the ANZAC ships and Collins class submarines into service. This focussed attention on the acceptance procedures, and consequently on the Operational Test and Evaluation (OT&E), of the new combatants. The United States Navy (USN) is the world leader in the development of high technology weapons systems and have extensive experience in their acquisition, testing and operation. As the RAN has a similar philosophical approach to acquisition and Test and Evaluation (T&E), the USN OT&E system forms a credible basis from which to develop an RAN OT&E organisation, policies and procedures capable of adequately assessing the operational effectiveness and operational suitability of the new combatants against the user requirement.

A. SHIP TEST AND EVALUATION

The fundamental purpose of T&E in a system's development and acquisition program is to identify the areas of technical risk to be reduced or eliminated. During the early phases of development, T&E is conducted to demonstrate the feasibility of conceptual approaches, to minimise design risk, to identify design alternatives, to

compare and analyse trade-offs, and to estimate operational effectiveness and suitability. As a system undergoes design and development, the emphasis in testing moves gradually from developmental test and evaluation, which is concerned chiefly with the attainment of engineering design goals, to operational test and evaluation, which focuses on questions of operational effectiveness, suitability and supportability. The principal types of T&E pertaining to ships as defined by the USN are:

1. Developmental Test and Evaluation (DT&E)

DT&E is conducted to assist the engineering design and development process and to verify attainment of technical performance specifications and objectives.

2. Production Acceptance Test and Evaluation (PAT&E)

PAT&E is testing conducted on production items to ensure systems meet contract specifications and requirements, usually for contractual acceptance purposes. It is a type of DT&E.

3. Operational Test and Evaluation (OT&E)

OT&E is conducted to determine a system's operational effectiveness and operational suitability, identify system deficiencies and the need for potential modifications to meet established OT thresholds, and develop tactics. OT&E has three distinguishing characteristics:

- It is conducted in an operationally representative environment.
- It is conducted on production representative equipment using fleet personnel for operation and maintenance.
- It is conducted against a threat-representative simulated enemy carrying out threat tactics per the latest threat assessment.

The focus of DT&E is on a system meeting technical and production specifications, while in OT&E, the focus is on assessing the actual functioning of the system in the realistic combat environment, against the user requirement.

B. OT&E ENVIRONMENT

The U.S. places a high priority on Defence with strategies of world leadership, global influence and self sufficiency. To achieve these strategies, the U.S. devotes a high percentage of its Federal expenditure to Defence, and places a high priority on Research and Development (R&D). The USN need for OT&E stems from its almost exclusive reliance on indigenous weapons development and production. It has a history of large, risky, developmental programs which push the state of the art in weapons technology. To minimise technical and operational risk, the outputs of these programs require the assessment of operational effectiveness and suitability against the user requirement before being committed to production and subsequent introduction into the Fleet.

Australia's Defence strategy has progressed from a position of dependence on allies, to a positive acceptance of both self-reliance and regional influence. To achieve its Defence goals, however, Australia devotes much less of its resources and places less priority on R&D than does the U.S. The need for local T&E is recognised by the Australian Government and DoD, for both indigenous and overseas systems, however, the importance of OT&E in particular, is not specifically addressed in any Australian T&E policy document. This lack of recognition of the importance of OT&E is perhaps due to the RAN procuring low risk, complete ships in the past (e.g., FFG-7 class) with the wealth of USN DT&E and OT&E behind it.

C. OT&E IN THE ACQUISITON PROCESS

The U.S. Defence system acquisition life cycle consists of progressive development phases separated by major decision milestones, when a program is reviewed and authorised to advance to the next stage. The USN OT&E system forms an integral part of the U.S. DoD acquisition process. It is an empirical method of ensuring a sufficient technical return on acquisition investment and for ensuring that a new system is fully capable of meeting the fleet's needs. As a result, the U.S. place high importance on OT&E, with its conduct being mandated by Congress and incorporated in the law of the U.S. OT&E is viewed as being more important as a basis for a decision to proceed beyond Low Rate Initial Production, than on the introduction into service of the final production item. This is because the "big bucks" of most Defence acquisitions are spent during the production phase. OT&E, however, has started to play an important role also in the assessment of first of class systems for introduction into the USN Fleet.

The USN and RAN have similar acquisition systems, however, the level of importance of T&E, and OT&E in particular, differs greatly. The Australian DoD prefers lower risk, proven technologies for the majority of new acquisitions. The Australian system, therefore, places a high T&E priority on the post production phase, with no mandatory requirement for OT&E prior to a production or purchase decision, but requiring OT&E before the first production system is Accepted into Naval Service (AINS). As Australia is now buying far less "off the shelf" systems from overseas, and systems are increasingly being designed and built in Australia or adapted from overseas designs, the operational risk of these systems is increasing. These greater risks place emphasis on OT&E leading to a production or purchase decision where the majority of a project's funding is spent.

D. OT&E ORGANISATION

The organisation of OT&E within the USN is complex with separate authorities performing a number of OT&E functions, as listed in Table 1.

TABLE 1: USN OT&E FUNCTIONAL AUTHORITIES

OT&E Function	USN Authority
Policy Maker & Overseer	Director, Operational Test & Evaluation (DoD authority)
Sponsor	Chief of Naval Operations
Developing Agency	Commander, Naval Sea Systems Command
Operational Tester & Evaluator	Commander, Operational Test & Evaluation Force
User	Fleet Commanders, Ships' Commanding Officers
Coordinator	Director, Test, Evaluation and Technology Requirements

Significant characteristics of this organisation include the appointment of a Director of OT& E (DOT&E) responsible for policy formulation, evaluation and oversight of OT&E within the U.S. DoD, and the inclusion of a coordinator for USN T&E. The USN also separates the OT&E and DT&E organisation structures.

Following a number of recent reorganisations, the RAN's OT&E structure is in disarray. There is no clear OT&E, or T&E, policy maker or overseer within the Australian DoD or the RAN. The Sponsor is not within the RAN organisation, being part of centralised force development and user requirements organisation (HQADF) who sponsors major RAN acquisitions, and is responsible for the initial determination of T&E requirements. The Developing Agency (ACMAT-N), unlike

its USN counterpart, does not have a T&E office to support Project Directors. With the disestablishment of the RAN Trials and Assessing Unit (RANTAU) in May 1992, the RAN's OT&E authority is now the Commander, Test and Evaluation (CTE) under the Chief Staff Officer (Engineering) (CSO(E)) in the Maritime Command. CTE is currently multifunctional, conducting DT&E and PAT&E in addition to OT&E. This results in a lack of differentiation within CTE's organisation between DT&E/PAT&E and OT&E. Also being placed under the in-service engineering area of the Maritime Command, he lacks visibility and influence within the warfare community and hence credibility in operational matters critical to OT&E. CTE's OT&E responsibilities are overshadowed by his DT&E/PAT&E duties. The RAN currently has no single authority who acts as a T&E focal point within Navy Office responsible for coordination of T&E matters, however, a project T&E manager does perform this function for his project.

In summary, the RAN and Australian DoD have reorganised over the past five years to create a more effective and efficient user requirements organisation, and to better accord with Program Management and Budgeting principles. However, as a result, the RAN has no T&E, or OT&E policy maker and overseer, no OT&E coordinator within Navy Office, and the RAN's OT&E authority is buried within the in-service engineering management area of the Maritime Command.

E. OT&E POLICY

Where USN OT&E policy has its basis in the statutes approved by Congress, the RAN has no such formal basis and its OT&E policy is embedded in the more general T&E policy. Some key aspects of this policy include:

1. OT&E Policy Documentation

The USN has a hierarchy of comprehensive OT&E policy documentation that provides clear, consistent and non-conflicting policies and guidance to OT&E participants, and establishes the disciplined management approach to OT&E taken by the USN. In contrast, the current RAN T&E policy documentation provides broad T&E policy only and, other than defining OT&E, provides little policy to guide its conduct. The RAN has adapted the more detailed USN T&E definitions to suit its own requirements. During this process, however, the RAN lost the distinction between the types of T&E, and often confuses OT&E with PAT&E/ DT&E. Overall, RAN T&E documentation is not comprehensive, inconsistent and fails to provide adequate guidance.

2. Independence of OT&E Authorities

Independence of OT&E authorities is the key to the effectiveness of OT&E in the U.S. acquisition process. OPTEVFOR, as the independent OT&E agency within the USN, reports directly to CNO, while DOT&E provides independent oversight and coordination of the military services' planning and execution of OT&E, reporting directly to the Secretary of Defence. The independence of the OT&E authorities is designed to ensure impartiality, and honest and open reporting, subject to the minimum of political interference.

Although major acquisition decisions within the RAN are less based on the results of OT&E, the RAN also maintains the policy that OT&E is to be conducted by an authority independent of the development and production agencies. CTE, on the staff of the Maritime Commander, is independent from the development and production agencies, but not from the end user, as in the USN. The implications of this lack of independence is that the end user may have his own aims and objectives which conflict with the total impartiality of OT&E conduct and reporting.

3. Foreign Weapons Evaluation

The USN has a foreign weapons evaluation program which is designed to support the evaluation of foreign weapons systems, equipment or technology in terms of its potential to meet specific U.S. military requirements. The primary objective of the program is to reduce the costs of research and development, while leading to the acquisition of foreign equipment for U.S. use. Despite the most recent Australian Government "White Paper" on Defence Policy requiring the need to be able to determine the performance in the Australian environment of equipment of both overseas and local origin, no DoD or RAN T&E policy specifically addresses the evaluation of foreign systems.

4. Land Based Test Sites (LBTS)

Although used primarily for the purpose of conducting DT&E, the USN has demonstrated that early OT&E on LBTS can give an estimation of potential operational effectiveness and suitability, and hence identify potential operational problems early and minimise operational risk. RAN guidance for OT&E using LBTS includes a statement that system centres and simulators will be employed for early stages of OT&E if available, and that OT-2 may be conducted at a land-based test site. The use of LBTS for OT&E during the ANZAC frigate and COLLINS submarine projects would appear to offer advantages to the RAN. However OT-2 in support of a production decision was not conducted for either the ANZAC frigate and Collins submarine project. Although LBTS are being developed for both projects, they were not available before production contracts for all the required combatants were signed. The use of these LBTS for early OT-3 also was not planned in the original project schedules, and so the conduct of OT&E is now subject to them being used on a non-interfering basis to the contractor. LBTS should be used for OT&E in the RAN to give an estimation of potential operational effectiveness and

suitability, and hence identify potential operational problems early and minimise operational risk. This should be conducted as the first phase of OT-3 during a dedicated period following the completion of DT&E on the LBTS.

5. Clear Delineation between T&E Types

The USN achieves a clear delineation between the different types of T&E. OPTEVFOR conduct only OT&E, and OT&E within the USN is conducted solely by OPTEVFOR. Thus, there appears to be good understanding in the USN of what is, and what isn't, OT&E. USN policy also states that combined DT&E/PAT&E and OT&E testing should only be considered when there are time and cost savings. In addition, this combined approach must not compromise either the developmental or operational test objectives, and separate evaluations and reports will be prepared by DT&E and OT&E testers. The conduct of combined and concurrent DT&E, (PAT&E) and OT&E is not addressed in RAN T&E policy, however, it is implied as being almost a requirement. The RAN does not clearly differentiate between the types of T&E, which leads to DT&E and OT&E often being conducted over the same period, by the same test team. Although the RAN recognises, by definition, the difference in objectives and methodology between the types of T&E, no limitations or guidance as to the possible hazards of this combined testing approach are addressed.

F. SHIP ACCEPTANCE

The purpose of ship acceptance in the USN is to ensure delivery to the Fleet of complete ships, free from both contractor and government responsible deficiencies. Independent verification of readiness of ships for acceptance is the responsibility of the President, Board of Inspection and Survey (PREINSURV) who conducts Acceptance Trials and Final Contract Trials for each individual new ship. Ship

acceptance has traditionally been based only on the successful completion of PAT&E and material inspections that, for the first of class, culminated in approval for Fleet Introduction. However, with the treatment of ships as a complete weapons system, as for the DDG-51, Fleet Introduction is now based also on OT&E results.

In the RAN, Delivery (contractual acceptance) of the ship to the Government is a contractual matter and is managed by the Project Director. This is followed by RAN trials to assess the ship for Acceptance into Naval Service (AINS). CTE's responsibility is to conduct the trials and report the results. An Acceptance Board (AB) is established to provide an assessment of the ship and submit recommendations upon which CNS can base his acceptance decision. The President, Vice-President and Board members serve on the AB part time, and the sole function of the AB is to advise CNS on acceptance matters. It does not conduct tests, trials or inspections, and is essentially a board of review. Similar to the USN, the RAN also places emphasis on PAT&E leading to AINS, although OT-3 has been included in the trials program. However, the trials conducted as OT-3 were really PAT&E / DT&E with minimal true OT&E content. For the first of class, OT-4 is conducted following AINS. It comprises a series of trials and evaluations over a 12 to 24 month period to assess operational effectiveness and operational suitability leading to Operational Acceptance.

The AB, with its broader experience and knowledge than CTE, is generally agreed within the RAN as being successful as a board of review of the planning and results of T&E for individual projects, and recommending the first of class for AINS. As an ad-hoc organisation consisting of various functional specialists brought together part time, however, the AB suffers from a number of problems. It requires guidance as to its role and functions, T&E philosophy and the procedures of the acceptance process. Although the AB attempts to obtain sufficient guidance from the T&E documentation, it has found this documentation to be unclear and

conflicting. With only DT&E/PAT&E and the minimal operational aspects of the OT-3 testing conducted by the RAN, the AB has tended to focus on materiel deficiencies, rather than the performance of the first of class against the user requirement.

G. OT&E PROCEDURES

1. Level and Extent of OT&E

The determination of the level and extent of OT&E required is a difficult question. The fundamental cornerstone of OT&E is the user requirement, generated through a series of documents built into the acquisition process. A requirement can be traced from the capability need through the refining requirements documentation to a specific objective in the TEMP, to the test plan, and ultimately to the final OT&E report. This linkage from capability need to operational test program defines the scope of testing necessary to evaluate the final product against the current user requirement.

2. Assessing Operational Effectiveness

Operational effectiveness is the capability of a system to perform its intended function effectively over the expected range of operational circumstances, in the expected environment, and in the face of the expected threat, including countermeasures where appropriate. The USN examines each Critical Operational Issue (COI) and decides what needs to be known to enable each issue to be assessed. It ensures that the appropriate environments, threats, etc. are included and that sufficient data will be generated to address the COI and objectives. It focuses on achieving statistical relevance and making the tests as objective as possible. The broad scope of many operational requirements, however, makes their testing and subsequent assessment rather subjective, making the determination of meaningful

and assessable quantitative Measures of Effectiveness (MOEs) difficult. In addition, a lack of resources may reduce an objective, quantitative, statistically relevant test schedule to a more subjective, qualitative assessment. These situations require expertise and judgement, and compromise between the authorities involved, to make the tests as objective as possible.

The RAN has found it difficult to define exactly what is required to assess operational effectiveness. The RAN recognises that the user requirement is the bench mark for determining the degree to which a system is effective, and also that operational effectiveness is best assessed by a performance demonstration by normal operating personnel in the normal or given environment. Assessing operational effectiveness has involved analysing each COI and then employing modified Ship Qualification Trial or Fleet Exercise Program techniques to evaluate them. The RAN has very little guidance on the assessment of operational effectiveness.

3. Assessing Operational Suitability

Operational suitability is the capability of a system, when operated and maintained by typical fleet personnel in the expected numbers and of the expected experience level, to be reliable, maintainable, operationally available, logistically supportable when deployed, compatible, interoperable and safe. The assessment of operational suitability in the USN consists of an Integrated Logistic Support (ILS) Plan review, followed by suitability testing based on the expected reliability, degree of confidence, thresholds, etc., required to be achieved. OPTEVFOR has analysts who design suitability tests and determine measures of suitability, and also evaluate and analyse the adequacy of logistic supportability. OPTEVFOR also relies on operational personnel to use their experience and knowledge of the system to identify inadequate logistic support.

Before 1987, the assessment of operational suitability, and ILS in particular, was rather subjective and often controversial in the RAN. A new approach was taken in 1987 to make the assessment of ILS more objective. The RAN is currently developing a routine in-service RM&A data collection and analysis system, however, until that is operational, the data is collected and analysed on an 'as required' basis by CTE.

In summary, the principles of operational suitability assessment are common between the USN and RAN. Although assessments by the RAN have become more subjective over recent years, the assessment of RM&A is still in its infancy. The RAN requires experienced personnel to design suitability tests and analyse results.

4. OT&E Planning

The RAN has embraced the U.S. TEMP concept as the single executive document for the management of T&E for major acquisitions. Although required early in a project, recent RAN TEMPs have not been raised until after project funding has been approved. TEMPS need to be approved earlier to enable inclusion of post delivery PAT&E/DT&E and OT-3 in the Project budget, and OT-4 in the Maritime Commander's budget. The authority for DCNS to release the TEMP was based on his role as Project Sponsor. With HQADF now assuming this role, the DCNS function in TEMP development is unclear. The TEMP approval process requires review.

The USN T&E Coordinator responsibilities include the chairmanship of the Test and Evaluation Coordination Group (TECG) for each major program. Some of the functions of a TECG are the early definition of terms, measures of effectiveness, and the acceptability criteria. In the RAN, a T&E Planning Group (TEPG) is formed prior to TEMP development to analyse T&E requirements and estimate the

resources required. The TEPG is similar to the USN TECG with one significant difference. The USN TECG is chaired by the USN T&E Coordinator under the CNO, whereas the RAN TEPG is chaired by each individual Project Director through his T&E manager. Despite their best intentions, Project Directors are essentially driven by cost and schedule considerations, not the overall T&E adequacy of their project. To be truly objective, each TEPG should be chaired by the authority responsible for ensuring the adequacy of the RAN's overall T&E program.

5. RAN OT&E Reporting

Reports provide the OT&E authority's conclusions regarding a system's operational effectiveness and suitability, and his recommendations regarding the systems future. The USN requires OT&E reports to be impartial, complete, thorough and be reported solely by the OT&E authority.

Within the RAN, the OT&E Authority coordinates the issue of trials reports, however, they are issued on completion of each segment of OT&E e.g., o/c ASW section of OT-3 etc., usually in addition to a report at the end of the OT phase. Quicklook reports are also routinely sent on completion of each week's testing. The ship under test also provides a report, however, it is usually forwarded to its operational authority and the Project, in addition to the OT&E Authority. This early dissemination of OT&E results, before a full analysis is complete and the implications assessed, can lead to other authorities taking hasty action on incomplete information, and can prejudice the OT&E authority's final conclusions and recommendations. OT&E results should indicate system deficiencies against user requirements rather than equipment defects, so the results need to be fully analysed and the implications assessed before being reported to a wider audience.

6. Whole Ship OT&E

The OT-III conducted on DDG-51 was the first time the USN has conducted OT&E on a whole ship in a multi-battle situation, in a free play environment. The whole ship was viewed as an integrated weapons system, rather than as a platform for weapons systems, and OT-III was conducted in a dedicated period following Ship Qualification Trials (SQT) and Final Contract Trials.

Within the RAN, the current OT&E to support an AINS decision (OT-3) is little more than an extended SQT period where DT&E/PAT&E is conducted with some operational assessment. It is not considered to be adequate to assess the first of a new ship class against the user requirement. To assess the operational effectiveness and suitability of a ship against the user requirement with the degree of confidence required for the Acceptance Board to support an AINS decision, a dedicated, free play, scenario based, OT-3 period is required.

a. OT&E Training

OT&E is a specialised discipline, with its own philosophy and methodology, and so requires a specialist approach with knowledge and experience to make it effective. COMOPTEVFOR conducts a three day Operational Test Directors' (OTD) course covering the major areas of OT&E. They also run irregular segment courses which provide overviews or updates on OT&E subjects e.g., analysis, test plan development and threat updates.

The RAN has no training courses on OT&E, or on T&E in general. A number of officers have completed the USN OTD course in recent years which has improved the knowledge and understanding of OT&E within CTE's organisation considerably. These courses have been arranged on an ad-hoc basis through overseas visit submissions rather than as pre-requisite courses for particular billets.

To be effective, OT&E requires experienced and knowledgable personnel with high professional credibility within their field of expertise. To achieve this requires selection of suitable personnel, adequate training and good guidance documentation, and preferably a career path where serving in the OT&E Authority is seen as career progression by such capable personnel.

H. CONCLUSION

The USN OT&E system has, by necessity, developed into a well organised, well documented and effective, if complex, system. The RAN system, on the other hand, suffers from confusing T&E policy documentation, a weak OT&E organisation structure and a general lack of OT&E knowledge and appreciation. The determination of OT&E required has traditionally not been achieved early enough in the life of a project, and so project funding has not included the provision for OT&E. The RAN OT&E system, although originally based on USN OT&E philosophy, now differs in the importance, interpretation, application and focus of OT&E. As a result of organisation changes, it now lacks the ability to effectively manage overall T&E, let alone OT&E, at a time when the operational risk of ship projects is increasing. To achieve efficient and effective trials and acceptance of the new higher risk warships currently under construction, the RAN OT&E system needs to be revised.

I. A RECOMMENDED MODEL FOR OT&E IN THE RAN

The OT&E model recommended for the RAN uses principles derived from the USN system. By taking consideration of resource limitations, and the characteristics and culture of the RAN, it establishes an effective OT&E organisation which is important to the testing, evaluation and subsequent acceptance decision of the new combatants.

1. T&E Definitions

The basis for this OT&E model are clear definitions of the types and phases of T&E. The current Australian definitions are amended and phases of T&E are refined to better suit the RAN environment. The following definitions of types and phases of T&E are proposed for the RAN system:

a. Developmental Test and Evaluation (DT&E)

The DT&E definition remains unchanged as follows:

DT&E is conducted to assist the engineering design and development process, and to verify attainment of technical performance specifications and objectives.

DT&E consists of the three phases listed in Table 2.

TABLE 2: DT&E PHASES

DT&E	Proposed RAN Description
DT-1	Validation of design concept.
DT-2	Demonstration that design meets specifications.
DT-3	Demonstration that production meets required technical characteristics or establish standards for first of class. PAT&E is a form of DT-3.

b. Production Acceptance Test and Evaluation (PAT&E)

The definition of PAT&E is revised to recognise that it is conducted not only during the contract period, but also during subsequent RAN testing:

PAT&E is conducted on production items to ensure systems meet technical specifications and requirements, and is a type of DT&E.

PAT&E consists of the seven phases listed in Table 3.

TABLE 3: PAT&E PHASES

PAT&E	Proposed RAN Description
PAT-0	Design and engineering development tests
PAT-1	Production and burn-in tests
PAT-2	Environmental qualification tests
PAT-3	System development tests
PAT-4	Harbour testing
PAT-5	Sea testing
PAT-6	Certification and Qualification Trials

c. *Operational Test and Evaluation (OT&E)*

The definition of OT&E is revised along USN lines, so that it more accurately describes the purpose and nature of OT&E.

OT&E is conducted to determine a system's operational effectiveness and operational suitability, identify system deficiencies and the need for potential modifications to meet established OT thresholds, and develop tactics. OT&E has three distinguishing characteristics:

- *It is conducted in an operationally representative environment.*
- *It is conducted on production representative equipment using fleet personnel for operation and maintenance.*
- *It is conducted against a threat-representative simulated enemy carrying out threat tactics per the latest threat assessment.*

OT&E consists of the five phases listed in Table 4.

TABLE 4: OT&E PHASES

OT&E	Proposed RAN Description
OT-1	Operational assessment of the development proposal to support Full Scale Engineering Development approval.
OT-2	Demonstration of achievement of program requirements for operational effectiveness and suitability to support a production or purchase decision.
OT-3	Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/aircraft/ system to support Acceptance into Naval Service. Includes limited reliability, maintainability, availability and logistic supportability assessments.
OT-4	Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/aircraft/ system in a multi-force, multi-threat environment to support Operational Acceptance. Includes detailed reliability, maintainability, availability and logistic supportability assessments.
OT-5	In-service OT&E, which could include new applications, new tactics, revised threat, etc.

2. T&E in the Acquisition Process

To ensure the progressive assessment of operational effectiveness and operational suitability during the acquisition process, OT&E is scheduled towards the end of each acquisition phase. The proposed T&E schedule, noting the distinction between DT&E/PAT&E and OT&E, is shown in Figure 1. No change is suggested to the current relationship between OT&E phases and acquisition milestones, however, the figure separates DT&E/PAT&E from OT&E to clearly differentiate these types of testing.

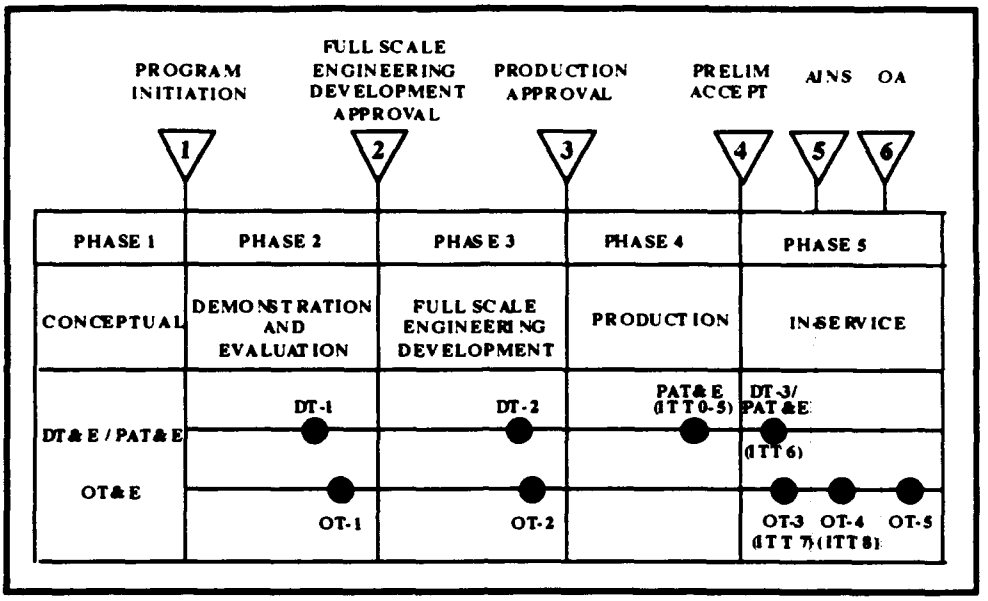

Figure 1: T&E in the Acquisition Process

a. Total Ship Test Program

The Total Ship Test Program (TSTP) concept, modified from the U.S. system, is now well established in RAN shipbuilding projects. The proposed T&E phases can be incorporated into an amended TSTP. However, instead of being grouped together as in the current TSTP, the DT&E and OT&E events are now shown as separate categories of testing. Because these separate DT&E, PAT&E and OT&E events are integrated within the overall TSTP, these trials are termed collectively as "Integrated Tests and Trials", which is an extension of the current RAN application of this term. Table 5 shows the proposed revised categories of ITT.

TABLE 5: CATEGORIES OF ITT

ITT Part	ITT Category	T&E Type	Description
ITT Part 1	ITT-0 *	PAT-0	Design and engineering development tests
	ITT-1	PAT-1	Production and burn-in tests
	ITT-2 *	PAT-2	Environmental qualification tests
	ITT-3 *	PAT-3	System development tests
	ITT-4	PAT-4	Harbour testing
	ITT-5	PAT-5	Sea testing
ITT Part 2	ITT-6	DT-3 / PAT-6	Certification and Qualification Trials
	ITT-7 *	OT-3	Operational T&E
ITT Part 3	ITT-8 *	OT-4	Follow on Operational T&E

Note: * Only performed on first of class

3. OT&E Organisation

The current OT&E organisation structure is modified to enable effective OT&E to support the acquisition process. It provides for authorities responsible for the management, policy making and oversight, specification and conduct of OT&E. This proposed reorganisation closely achieves the aim of DT&E/OT&E separation, and is shown in Figure 2.

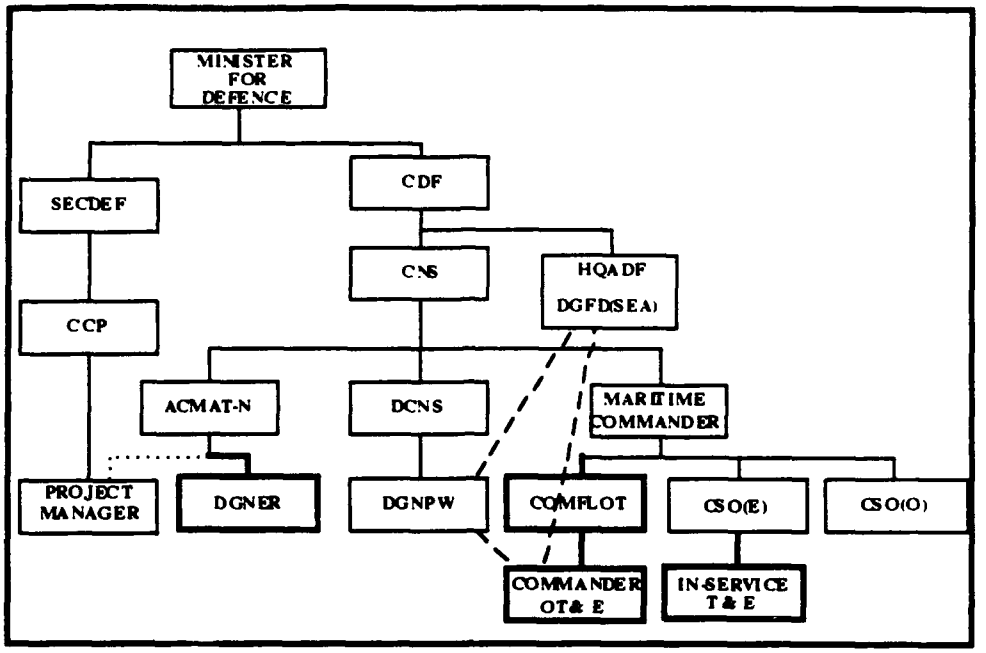

Figure 2: Proposed RAN OT&E Organisation

Ideally, the head policy maker and overseer of OT&E should be within HQADF or DoD, along the lines of the U.S. system. A shorter term, RAN-only solution would be to include this function within the revised Director General Naval Policy and Warfare (DGNPW) organisation under the Deputy Chief of Naval Staff (DCNS). The Sponsor of major naval acquisitions is the Director General Force Development (Sea) (DGFD(Sea)) within HQADF. To be able to determine the appropriate nature and extent of OT&E required, the Sponsor needs access to OT&E knowledge and experience. A close relationship needs to be maintained by DGFD(Sea) with the OT&E policy maker and the OT&E authority (Note dotted line). To assist all RAN projects with T&E matters, an authority is required within the Materiel Division, under the Assistant Chief of Naval Staff - Materiel) ACMAT-N), whose responsibilities include assisting Project Directors in complying with

policies, incorporating lessons learned from previous projects and reviewing the T&E aspects of projects at major milestones. Although primarily a DT&E policy authority, this office would also have an input into the OT&E process by reviewing the TEMP, and by advising projects how to prepare for OT&E. The Director General Naval Engineering Requirements (DGNER) is currently responsible for the design, development, acceptance into service and through life support of ships. This engineering policy directorate appears to be well suited to the DT&E policy and review function.

The current OT&E Tester and Evaluator, CTE, within the Maritime Command is multifunctional, performing both DT&E/PAT&E and OT&E. To achieve the advantages of DT&E and OT&E separation, a revised organisation is proposed. All CTE's current DT&E/PAT&E responsibilities, and those already the responsibility of CSO(E), would remain with an in-service trials team under CSO(E). CTE's OT&E duties would be removed and managed by a separate group, Commander, OT&E (COT&E), working under an operational authority. As OT&E is the assessment of operational effectiveness and suitability, COT&E should be responsible to COMFLOT. Headed by a Warfare branch officer, COT&E would manage the post delivery trials period for all ships from the MHQ perspective. He would still manage the SQT, which, although not true OT&E, still has some operational input which could not be met by the in-service trials team under CSO(E).

This proposed reorganisation closely achieves the aim of DT&E/OT&E separation with some concessions necessary to limit manpower requirements. Also, by including OT&E managed by a Warfare Officer under COMFLOT, OT&E could achieve visibility, credibility and influence within the RAN.

4. RAN OT&E Policy

a. Policy Documentation

To correct the current inconsistent and out of date T&E documentation, a major rewrite, rather than just updating is required. This rewrite could be the vehicle by which the T&E system within the RAN is overhauled, as before the documentation is revised, T&E definitions and terminology need to agreed within the RAN and DoD. Then the OT&E and DT&E organisations within the RAN need to be resolved, and the appropriate policies decided.

b. Independence of OT&E Agency

Given the proposed COT&E is organisationally independent from the developing and production agencies, his procedural independence should also be maintained to ensure impartiality and validity of testing. When OT&E is conducted, it should not be influenced by the Project or Design Approval Authority (DAA). No Project or DAA personnel should be present during testing. A final report only should be issued by the Maritime Commander, with no progress or interim report (unless the testing is unusually lengthy), to allow full analysis and evaluation of the test results. Similarly, to ensure test validity and impartiality, contractors should not be present during OT&E.

5. T&E Planning

Test and Evaluation Master Plans (TEMPs) would be approved early to enable inclusion of post delivery PAT&E/DT&E and OT-3 in the Project budget, and OT-4 in the Maritime Commander's budget. To be truly objective, each TEPG would be chaired by the authority responsible for ensuring the adequacy of the RAN's overall T&E program. The proposed RAN OT&E policy maker and overseer, DGNPW, may best be suited to the chairmanship of each TEPG.

6. Land Based Test Sites

OT&E would be conducted during a dedicated period in the LBTS following successful DT&E, to gain an estimate of the potential operational effectiveness and suitability of the system. This period would be planned early so as to be included in Project schedules and funds.

7. Whole Ship Testing

To assess the operational effectiveness and suitability of a ship against the user requirement with the degree of confidence required for the Acceptance Board to support an AINS decision, a dedicated, free play, scenario based, OT-3 period is proposed. This OT-3 would be conducted after the ship has completed the SQT, Workup and Operational Readiness Evaluation to ensure that the testing is conducted on a worked up and materially proven ship. OT-3 would be conducted of the overall ship as a complete weapons system.

8. RAN Ship Acceptance

The AB would be convened for the first of class only, providing the specialist expertise to interpret requirements and determine the level of acceptability required for AINS. The AB consists of Naval Officers drawn part-time from their normal jobs, and so the cost appears to be minimal. The AB, however, has a high opportunity cost, which is the value of the next best alternative on which the members could be working instead of serving on the Board. Once the first of class is accepted the Board's task is complete. The interpretations and levels of acceptability established by the AB then guide the Trials Authority in recommending acceptance of each of the remaining ships. With a more comprehensive OT-3 period proposed to be conducted, the AB members would more effectively use their knowledge and experience in assessing the results of OT&E against the user

requirement rather than on workmanship and materiel deficiencies. The AB should remain as a board of review.

9. RAN OT&E Procedures

a. Assessment of Operational Effectiveness

With the proposed inclusion of a dedicated OT-3 period, the OT&E authority will need to develop tests for a free play, scenario based environment specifically designed to assess the COIs against the User Requirements. The analysis of these tests may be different from the weapons analysis currently performed.

b. Assessment of Operational Suitability

The assessment of operational suitability, especially for the RAN's current combatant projects, would focus on interoperability and compatibility as these present the highest risks with the integration of proven equipment in a unique combination in a ship platform. RM&A data is collected and analysed during OT-3 to give an indication of performance prior to AINS, and then continued for 12 months during the OT-4 phase. The data would continue to be collected and analysed on an "as required", rather than on a continuous basis by the Trials Authority until the RAN develops its routine in-service RM&A data collection and analysis system. The analysis of RM&A data is a specialist task, currently outside the experience of most uniformed personnel. To achieve significant and valid results, an improved RM&A analysis capability would be established.

c. OT&E Training

A formal course such as the USN Operational Test Directors Course should be a pre-requisite for key billets within the OT&E authority until the RAN develops enough knowledge and expertise to develop its own course. Other

authorities also require training in OT&E. The OT&E authority should develop acquaint courses for other personnel with a need to understand OT&E. Also to increase the awareness of OT&E in the RAN, the OT&E authority would deliver presentations regularly to Project Directors Courses, the ILS Management and Acquisition Course (ILSMAC), Defence management courses, and other appropriate acquisition courses.

The proposed change of the head of the OT&E authority to a Warfare Officer as COT&E would provide a career path within the authority. As the credibility of OT&E increases within the warfare community, the knowledge and experience gained by warfare officers in this area will be seen to be of more benefit in future warfare related positions. The proposed employment of COT&E under COMFLOT should also be more career enhancing for warfare personnel than the current arrangement under CSO(E).

The professionalism and knowledge of T&E personnel could be enhanced by membership in a related professional organisation. The corporate membership of a suitable professional organisation may be worthwhile to the RAN.

J. RECOMMENDATIONS

It is recommended that the proposed OT&E model be reviewed, evaluated and implemented in the RAN to achieve an effective OT&E system to support the introduction of operationally effective and operationally suitable new combatants into the RAN.

1. OT&E Definitions

It is recommended that:

a. the current definitions and phases of ship T&E be amended to better suit the Australian Defence environment.

b. the current TSTP be revised to show DT&E and OT&E events as separate categories of testing, and these trials be termed collectively as Integrated Tests and Trials (ITT).

2. OT&E Documentation

It is recommended that:

a. the RAN T&E DI(N) and ABR 1921 be revised to achieve comprehensive and consistent T&E policy guidance.

3. OT&E in the Acquisition Process

It is recommended that:

a. OT&E be conducted, where possible, prior to the production or purchase decision in the acquisition process to minimise risk.

b. OT-3 be separated from the DT&E /PAT&E post delivery trials.

c. OT-3 be conducted as a dedicated, free play, scenario based period after the completion of SQT and ORE to ensure testing is conducted on a worked up and materially proven ship.

d. OT-3 of the overall ship be conducted as a complete weapons system.

4. OT&E Organisation

It is recommended that:

a. the appointment of a DoD OT&E policy maker and overseer within HQADF be investigated.

b. DGNPW be appointed as the OT&E policy maker and overseer within the RAN.

c. a close working relationship on T&E matters be required between DGFD(Sea), DGNPW and the OT&E authority.

d. DGNER be appointed as the Materiel Division T&E agency to assist Project Directors in complying with policies, incorporate lessons learned from previous projects, review the T&E aspects of projects at major milestones, and advise projects how to prepare for OT&E.

e. the current CTE organisation be disestablished.

f. an "In-service Trials" team be established under CSO(E) to conduct CTE's current DT&E/PAT&E responsibilities, and those already the responsibility of CSO(E).

g. Commander, OT&E (COT&E) be established as the RAN's OT&E authority under COMFLOT, to manage OT&E and the post delivery trials period for all ships from the MHQ perspective.

5. OT&E Policy

It is recommended that:

a. policy be developed to enable the performance in the Australian environment of foreign equipment to be evaluated efficiently, effectively and consistently.

b. the TEMP approval process be reviewed to ensure appropriate authorities are consulted and approve the TEMP.

c. the TEPG be chaired by DGNPW as the authority appointed to ensure the adequacy of the RAN's overall T&E program.

d. OT&E not be influenced by the Project or DAA, and that Project or DAA personnel not be present during testing.

e. contractors not be present during OT&E.

f. TEMPs for non-development projects be approved before production approval to enable inclusion of post delivery PAT&E/DT&E and OT-3 in the Project Budget, and OT-4 in MHQ budget.

g. OT&E be conducted during a dedicated period in the LBTS following successful DT&E, to gain an estimate of the potential operational effectiveness and suitability of the system.

6. Ship Acceptance

It is recommended that:

a. the Acceptance Board remain as a board of review.

b. the Acceptance Board be convened for the first of class only.

7. OT&E Procedures

It is recommended that:

a. The OT&E authority develop tests for a free play, scenario based environment specifically designed to assess the COIs against the user requirement.

b. analysis requirements of these tests be assessed, as they may be different from the weapons analysis currently performed.

c. experienced personnel assist in designing suitability tests and analysing results.

d. interoperability and compatibility be a major focus during the assessment of operational suitability, especially for the RAN's current combatant projects.

e. an improved RM&A analysis capability be established.

f. RM&A data continue to be collected and analysed on an 'as required' basis until the RAN develops its routine in-service RM&A data collection and analysis system

g. OT&E reports be made solely by the OT&E authority.

h. OT&E phase reports be issued only, with no progress or interim reports, to allow full analysis and evaluation of the test results.

i. the USN Operational Test Director type course be a prerequisite for key billets within the OT&E authority until the RAN develops enough knowledge and expertise to develop its own course.

j. the OT&E authority develop acquaint courses for other personnel with a need to understand OT&E.

k. the OT&E authority deliver presentations regularly to Project Directors Courses, the ILS Management and Acquisition Course (ILSMAC), Defence management courses, and other appropriate acquisition courses, so to increase the awareness of OT&E in the RAN.

l. a Warfare Officer be appointed to head the OT&E authority.

m. establishing corporate membership of a suitable professional T&E organisation be investigated.

I. INTRODUCTION

A. BACKGROUND

1. Introduction

Friday, May 15, 1992 marked the end of an era for Operational Test and Evaluation (OT&E) in the Royal Australian Navy (RAN). The RAN Trials and Assessing Unit (RANTAU), the RAN's Operational Test and Evaluation authority, ceased to exist as an independent unit and was integrated with Maritime Headquarters (MHQ) under the Commander, Test and Evaluation.[Ref. 56]This marks a continuing shift in the emphasis placed on OT&E within the RAN.

2. Field of Study

The fundamental purpose of Test and Evaluation (T&E) in a system's development and acquisition program is to identify the areas of technical risk to be reduced or eliminated. Operational Test and Evaluation is the means to demonstrate that a ship meets the specified user requirement before being Accepted into Naval Service (AINS). This study analyses USN and RAN Ship OT&E organisation, methodology, and procedures, and then compares and contrasts the two systems. From this analysis, a model for OT&E in the RAN is proposed.

3. Importance of Research Effort

In September 1991, the Chief of Naval Staff (CNS) expressed concern that the RAN may not be capable of adequately managing the comprehensive and complex procedures necessary to accept the ANZAC frigates and Collins class submarines into service [Ref. 62]. With these new classes of surface and sub-surface combatants under construction, and the RAN currently reorganising its OT&E

organisation, the RAN could benefit from a timely analysis of USN and RAN Ship OT&E. The study is designed to assist the RAN to develop an effective and efficient OT&E organisation.

B. OBJECTIVES

OT&E is conducted to determine a system's operational effectiveness and operational suitability, to identify system deficiencies and the need for potential modifications to meet established operational test thresholds, and to develop tactics. It is usually conducted at the end of each phase of the acquisition process to support a major milestone decision. The more significant of these is the OT&E conducted on a prototype to support a production or purchase decision, and on the first of class to support an Acceptance into Naval Service decision (AINS). OT&E is conducted against the current user requirement and is definitive feedback to the program's sponsor that the system has met the user requirement.

OT&E has a high level of representation within the U.S. Department of Defence and the USN. The Director, Operational Test and Evaluation, has direct responsibility to the Secretary of Defence for prescribing policies and procedures governing the conduct of OT&E in the Department of Defence, and is a member of the Defence Acquisition Board. The USN has a dedicated command, the Commander Operational Test and Evaluation Force (COMOPTEVFOR) responsible to the Chief of Naval Operations (CNO) for Ship OT&E.

The RAN is currently reorganizing it's OT&E authority. Prior to May 1992, the RAN Trials and Assessing Unit (RANTAU) was responsible to the Naval Warfare Branch, as the originator of user requirements, for the planning, conduct and reporting of OT&E. However, RANTAU has recently been disbanded and the OT&E component transferred to the RAN Maritime Commander - the eventual ship "user".

Problems were experienced in the RAN with a perceived lack of high level representation and consideration of the OT&E requirements during the early phases of programs, with the cost and time effectiveness of OT&E, with the conduct of OT&E and Developmental Test and Evaluation (DT&E) concurrently, and with differences between acceptance of an item from a contractor (Delivery) and Acceptance into Naval Service.

The RAN is a comparatively small navy with limited resources. With large indigenous programs including the new Collins class submarines and ANZAC class frigates due to undertake OT&E in the near future, it is imperative that the RAN has a cost effective and efficient OT&E organisation.

This study compares the USN and RAN OT&E systems and highlights strengths and weaknesses of each. The methodology and procedures currently used by each Navy for the assessment of both operational effectiveness and operational suitability are analysed. The lessons learned from OT&E of the most recent USN ship program, the DDG-51, and the RAN DDG Modernization and Australian Frigate programs are reviewed. Then, using the results of this analysis, the current RAN plan for the OT&E of the ANZAC class frigate and Collins class submarine are reviewed. The output of the study is a model for the organisation and conduct of Ship OT&E in the RAN.

C. THE RESEARCH QUESTION

The primary research question posed in this thesis is "What are the fundamental characteristics of USN ship OT&E and how may USN experience in OT&E be applied to achieve an efficient, effective OT&E organisation for the RAN?" However, to address the fundamental characteristics of OT&E, a number of subsidiary research questions need to be answered. Some of the possible questions follow. How does OT&E support the Defence acquisition process? What are the

fundamental characteristics of the USN OT&E organisation? What are the fundamental characteristics of USN OT&E policy? What are the fundamental characteristics of USN OT&E procedures? How is USN OT&E implemented? How does OT&E support the acceptance of ships into the USN Fleet? How do the USN and RAN OT&E systems currently compare? What needs to be done in the RAN to achieve an effective OT&E system with a minimum of additional resource requirements?

D. SCOPE, LIMITATIONS AND ASSUMPTIONS

The scope of this thesis is limited to the study of OT&E for naval warships and submarines. Although based on the same philosophy, the OT&E of aircraft and equipment is not addressed. Although other nations conduct OT&E (e.g., United Kingdom), this study is limited to the analysis of USN and RAN OT&E systems only. This study is an overview of OT&E organisation, methodology and procedures. It does not address specific implementation matters or details of individual tests or trials. This study is limited to UNCLASSIFIED material only, and the collection of RAN information was limited to written and verbal correspondence as no personal interviews were able to be conducted with RAN authorities. No substantial increase of RAN OT&E resources in the near future was assumed.

E. WHY STUDY USN OT&E?

Study of the USN OT&E system could be beneficial to the RAN for a number of reasons. Due to the RAN's long association with the USN and its purchase of U.S. ships and equipment, it has a similar philosophical approach to acquisition and T&E. The basis of much of the current RAN T&E policies, methods and procedures is derived from the USN.

Technology is changing the face of modern warfare, and the USN is at the leading edge of this movement, adapting the best of new technologies to proven concepts and platforms. The USN strives to ensure that, as technology evolves, it is used to best advantage. As OT&E determines a new system's operational effectiveness and operational suitability, the need for potential modifications to meet established OT thresholds, and develops tactics, it is a critical part of adapting technology to modern warfare.

Being the most modern and capable naval force in the world today, the USN has substantial weapons system acquisition, operational and combat experience. This experience has confirmed their need for OT&E, and refined their OT&E organisation, policies, procedures and methodology. The RAN could benefit from this experience.

The USN are world leaders in the development of high technology weapons systems and have extensive experience in their acquisition, testing and operation. As the RAN has a similar philosophical approach to acquisition and T&E, the USN OT&E system forms a good basis from which to develop an RAN OT&E organisation, policies, procedures and methodology.

F. RESEARCH METHODOLOGY AND LITERATURE REVIEW

A balanced research methodology was used following the general research guidance outlined in Reference 1. The research consisted of three strategies:

1. Archival Research

Archival research consisted of examining the relevant formal documents pertaining to OT&E in both navies. This included a review of U.S. Defence Acquisition law, followed by review of the U.S. DoD and USN official documentation, pertaining to T&E, and to ship OT&E in particular. A similar

approach was taken in reviewing the Australian documentation. Also, a literature search was conducted to elicit the latest published views and opinions on OT&E. This search was conducted through two primary sources:

a. Database Search

A search was conducted with DIALOG Information Services, a commercial information service available through the Dudley Knox Library, Naval Postgraduate School. The DIALOG service is a computer database accessible by modem. The search was conducted using a number of key words including Operational and Evaluation, policy, procedures, and destroyer and frigate. A listing of 200 recent items was provided [Ref. 2].

b. Defence Logistics Studies Information Exchange

The Defence Logistics Studies Information Exchange (DLSIE), located at the U.S. Army Logistics Management College, Fort Lee, Virginia, is a U.S. DoD organisation that acquires, organises, stores and disseminates logistics and management information on a DoD wide basis [Ref. 3]. A custom bibliography was requested on the subject of ship Operational Test and Evaluation. A listing of 48 studies and reports on the subject was provided [Ref. 4].

Other sources of information included journals of professional organisations and Defence magazines, however, the most useful guidance to relevant publications was provided by personnel involved in OT&E. In summary, the archival research established the current, formal organisation, methodology and conduct of OT&E in both navies, and identified the latest public opinions on OT&E issues.

2. Personal Interview Research

Ship OT&E is a highly specialised, evolving field of expertise. Many developments are not published formally by DoD or in the commercially available literature. It was necessary, therefore, not only to survey the literature on the subject, but also to conduct interviews. This research was conducted by personal interviews, either in person or over the phone, with key participants in the ship OT&E field. Views and opinions were sought from authorities in both navies who either conduct, use the results of, or are otherwise effected by ship OT&E. The list of pertinent references as well as personnel interviewed are contained in the References section of this thesis.

3. Research Analysis

Research analysis was then applied to the information gathered by the other two strategies, to assess the information, evaluate the strengths and weaknesses of each system, and to develop the OT&E model. This analysis consisted of breaking down the USN and RAN OT&E systems into their component parts, in order to determine how (and where possible, why) the systems are organised, and particular procedures and methods used. An OT&E model for the RAN was then developed from the results and conclusions of the research analysis. As the RAN has a similar philosophical approach to acquisition and T&E to the USN, their OT&E system forms a good basis from which to further develop RAN OT&E organisation, policies, procedures and methodology.

G. DEFINITIONS AND ABBREVIATIONS

Terms important to the analysis of OT&E systems in the RAN and USN are defined as they are introduced. A list of acronyms is included in Appendix B.

H. ORGANISATION OF THESIS

The study initially reviews the background of OT&E in Chapter II. The purpose of T&E in Defence acquisition is discussed and the types of T&E applicable to ships are introduced. The U.S. and Australian strategic, economic and Defence environments are discussed briefly and compared. Some similarities and differences between the USN and RAN are also noted. The philosophy, organisation and management of OT&E within the USN and RAN are then analysed in Chapters III and IV respectively. A comparative analysis of USN and RAN OT&E systems is included in Chapter V. As result of this analysis, a model for OT&E in the RAN is proposed in Chapter VI. Chapter VII details the conclusions and Chapter VIII lists the recommendations.

II. OPERATIONAL TEST & EVALUATION BACKGROUND

This chapter presents background information considered necessary for a better understanding of OT&E. The purpose of T&E in Defence acquisition is discussed and the types of T&E applicable to ships are introduced. The U.S. and Australian strategic, economic and defence environments are discussed briefly and compared. Some similarities and differences between the USN and RAN are also noted.

A. PURPOSE OF T&E IN DEFENCE ACQUISITION

The fundamental purpose of T&E in a defence system's development and acquisition program is to identify the areas of technical risk to be reduced or eliminated. During the early phases of development, T&E is conducted to demonstrate the feasibility of conceptual approaches, to minimise design risk, to identify design alternatives, to compare and analyse trade-offs, and to estimate operational effectiveness and suitability. As a system undergoes design and development, the emphasis in testing moves gradually from developmental test and evaluation, which is concerned chiefly with the attainment of engineering design goals, to operational test and evaluation, which focuses on questions of operational effectiveness, suitability and supportability. [Ref. 18:p. 1-1] A primary contribution made by T&E is the identification and reporting of deficiencies that may adversely impact the performance capability, availability or supportability of a system.

T&E serves a number of useful functions, providing information for the following customers:

- Developers to assist in the identification and resolution of technical difficulties.

- Decision makers responsible for making the investment decision to procure a new system and for deciding on the most effective use of limited resources.
- Operational users to support the development of effective tactics, doctrine and procedures. [Ref. 18:p. 1-1]

B. TYPES OF SHIP TEST AND EVALUATION

The principal types of T&E pertaining to ships are:

1. Developmental Test and Evaluation (DT&E)

DT&E is conducted to assist the engineering design and development process and to verify attainment of technical performance specifications and objectives [Ref. 11:p. 3].

2. Production Acceptance Test and Evaluation (PAT&E)

PAT&E is testing conducted on production items to ensure systems meet contract specifications and requirements, usually for contractual acceptance purposes. It is a type of DT&E [Ref. 11:p. 5].

3. Operational Test and Evaluation (OT&E)

OT&E is conducted to determine a system's operational effectiveness and operational suitability, identify system deficiencies and the need for potential modifications to meet established operational thresholds, and develop tactics [Ref. 11:p. 5A]. OT&E has three distinguishing characteristics:

- It is conducted in an operationally representative environment.
- It is conducted on production representative equipment using fleet personnel for operation and maintenance.
- It is conducted against a threat-representative simulated enemy carrying out threat tactics per the latest threat assessment.

4. The Difference between DT&E and OT&E

DT&E is focused on a system meeting technical and production specifications, while in OT&E, the focus is on assessing the actual functioning of the system in the realistic combat environment, against the user requirement. Figure 1 illustrates this principal difference between DT&E and OT&E.

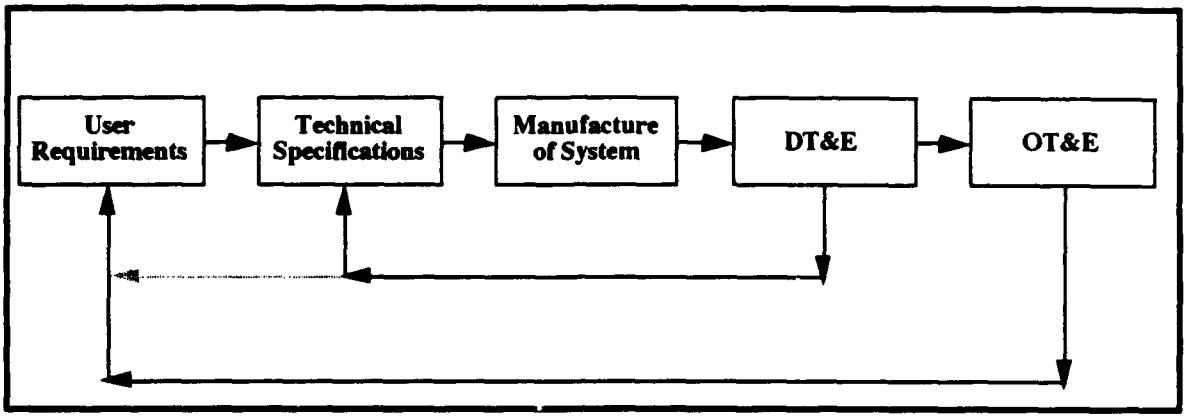

Figure 1: DT&E and OT&E Comparison

DT&E is planned and monitored by the developing agency and is normally initiated by the contractor. It includes the T&E of components, sub-systems and hardware and software integration, as well as preproduction and production qualification testing. OT&E, on the other hand, is conducted by an organisation that is independent of the developer, on the complete system in as operationally realistic an environment as possible, with hostile forces representative of the anticipated threat and with typical users operating and maintaining the system. Table 1 highlights the differences between DT&E and OT&E.

TABLE 1: DIFFERENCES BETWEEN DT&E AND OT&E [Ref. 18:p. 3-5]

DT&E	OT&E
Controlled by Program Manager	Controlled by Independent Agency
One-on-One Tests	Many-on-Many Tests
Sterile Controlled Environment	Tactical Environment with Operational Scenario
Contractor Involvement	No Contractor Involvement
Trained Experienced Operators	Users Recently Trained on System
Specific Performance Measurements and Goals	Operational Effectiveness and Operational Suitability Performance Measurements

To further highlight the difference between DT&E and OT&E, this anecdote, originally from the Air Force Manual 55-43, 1979 and reprinted in the U.S. Defence Systems Management College Test and Evaluation Guide [Ref. 18:p. 3-3] is an account of what is probably the first operational test and evaluation:

> The test and evaluation of aircraft started with the contract awarded to the Wright brothers in 1908. This contract specified a craft which would lift two men with a total weight of 350 pounds, carry enough fuel for a flight of 125 miles, and fly 40 miles per hour in still air. The contract also required that testing be conducted to assure this capability. What we now call DT&E was satisfied when the Wright brothers (the developer) demonstrated that their airplane could meet those first contract specifications. However, no immediate military mission had been conceived for the Wright Flyer. It was shipped to Fort Sam Housten, Texas where Captain Benjamin D. Foulois, the pilot, had orders to "teach himself to fly". He had to determine the airplane's performance, how to maintain it, and the kind of organisation that would use it. In the process, Captain Foulois subjected the Wright Flyer to test and evaluation in operational conditions. Foulois soon discovered operational deficiencies. For example, there was no seat on the airplane. During hard landings, Foulois' 130 pound frame usually parted company from the airplane.

To correct the problem, Foulois bolted an iron tractor seat to the airplane. The seat helped but Foulois still toppled from his perch on occasion. As a further improvement, Foulois looped his Sam Browne belt through the seat and strapped himself in, Ever since then, contoured seats and safety belts - a product of this earliest "operational" test and evaluation - have been part of the military airplane.

5. Operational Effectiveness and Operational Suitability

A system's operational effectiveness and operational suitability are the fundamental objects of OT&E. The USN and RAN definitions (which are possibly derived from the USN) for these terms are similar.

a. Operational Effectiveness

(1) USN Definition. Operational effectiveness is the capability of the system to perform its intended **function effectively** over the expected range of operational circumstances, in the expected environment, and in the face of the expected threat, including countermeasures where appropriate[Ref. 11:p. 8].

(2) RAN Definition. Operational Effectiveness is the capability of the system to perform its intended **function to the required standard,** over the expected range of operational circumstances, in the expected environment, and in the face of the expected threat including countermeasures[Ref. 44:p. A-1].

A subtle difference between these definitions is in the description of the assessed standard. The USN uses the term "effectively", meaning to do the job regardless of meeting specification, whereas the RAN uses the term "to the required standard", meaning to meet the specification.

b. Operational Suitability

(1) USN Definition. Operational suitability is the capability of the system, when operated and maintained by typical fleet personnel in the expected

numbers and of the expected experience level, to be reliable, maintainable, operationally available, logistically supportable when deployed, compatible, interoperable, and safe[Ref. 11:p. 9].

(2) RAN Definition. Operational suitability is the capability of the system, when operated and maintained by operational personnel in the expected numbers and of the expected experience level, to be reliable, maintainable, operationally available and logistically supportable [Ref. 44:p. A-2] in the specified environment within a specified time period.[Ref. 38:p. 14A-3]

The relationship of operational effectiveness and operational suitability to OT&E, and the major questions addressed in OT&E are shown in Figure 2.

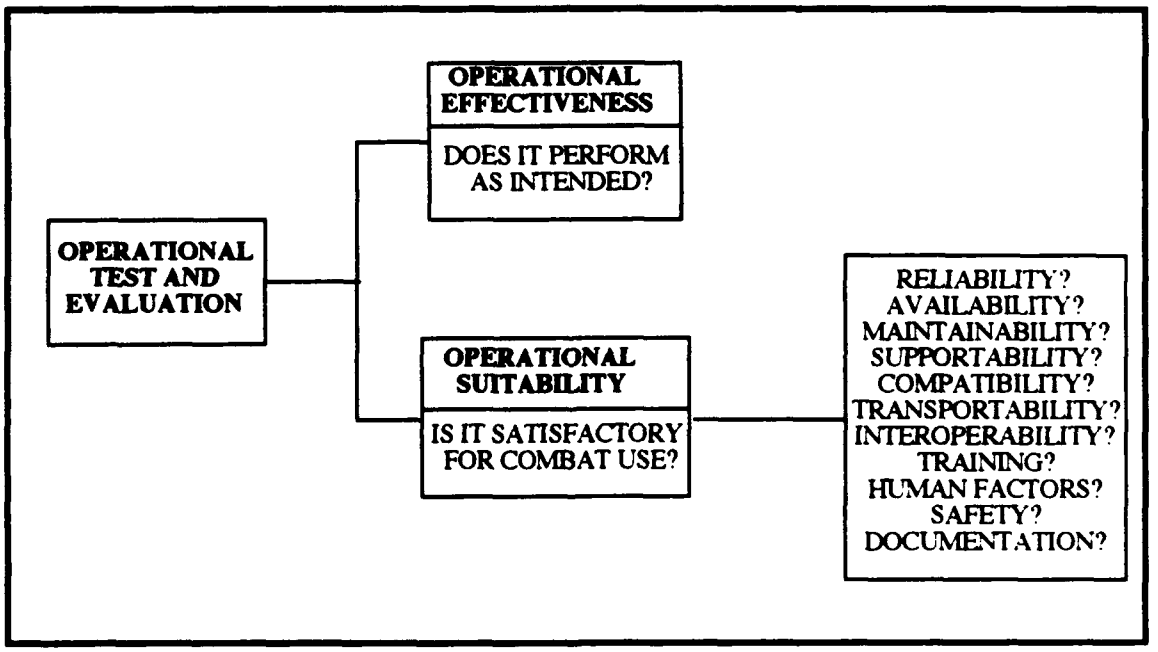

Figure 2: Questions Addressed in OT&E [Ref. 18:p. 3-6]

C. AUSTRALIA'S DEFENCE ENVIRONMENT

The recently publicly released "Australia's Strategic Planning in the 1990's" [Ref. 5] has not identified a specific military threat to Australia in the foreseeable future. It does, however, identify significant uncertainties concerning the future shape of the Australian strategic environment.

1. Strategy

Australia's national strategic policy has evolved over recent decades. It has come from a position of defence dependence on allies through concentration on the immediate needs of self defence to a positive acceptance of both self-reliance and regional influence [Ref. 5:p. 3]. The latest Australian Defence Corporate Plan [Ref. 8] highlights three central elements in Australia's defence policy:

- Self Reliance
- Regional Cooperation
- Strong Alliances

Self reliance accords priorities to meeting credible levels of threat in Australia's area of direct military interest [Ref. 6:p. vii]. Regional cooperation ensures strategic stability and security in the region, while strong alliances express common security interests and provide avenues for defence access and strategic influence. Close defence relations with the U.S. remain central to the policy of defence self-reliance. Although Australia does not depend on the U.S. for protection, it derives significant benefits from close collaboration through access to advanced technology, training and exercises, and intelligence. These benefits give Australia a level of capability that would be difficult and more costly for it to achieve alone. [Ref. 8:p. p 5]

2. Australian Defence Budget and Policies

To achieve its defence goals, Australia's defence budget for 1992-93 is $A 9.8 billion. This accounts for about 9% of Federal outlays and is equivalent to 2.4% of the expected GDP. [Ref. 8:p. 23] Australia is placing emphasis on capital investment, devoting 27.3% of its defence budget. It intends to maintain capital investment at about $A 2.5 billion per year, of which about $A 2 billion is on capital equipment. Along with this significant investment in new capabilities, Australia is now buying far less "off the shelf" from overseas, with systems increasingly being designed and built in Australia, or adapted from overseas designs. [Ref. 8:p. 17] As a result, Australian is now building frigates and submarines due to enter service in the mid 1990's.

The Australian Government's forward estimates indicate that the Defence Budget will be reduced by 0.5% in 1993-94 and then maintained at this level in real terms in 1994-95 and 1995-96 [Ref. 8:p. 24]. Over the four years to 1996, reductions of up to 6,600 permanent military personnel (about 10% of total force) and 1785 Defence civilians (about 8%) are anticipated [Ref. 8:p. 14].

The area over which the Australian Defence Force (ADF) needs to operate, the importance of denying an adversary freedom in the sea and air approaches, Australia's limited population base and the characteristics of the northern Australian area, place a premium on technologically advanced systems rather than manpower intensive forces. As the costs of local development and production of technologically advanced systems are high, development emphasis is placed on those areas unique to Australia or where particular skills have ongoing relevance to a range of defence capabilities.[Ref. 5:pp. 28, 38]

In summary, Australia is contributing to its strategic goals and ensuring that the ADF remains a formidable military force in regional terms, by maintaining

priority on capital investment. The focus is towards a smaller and more technology oriented force, with a more streamlined and effective organisation. Therefore, Australia needs to ensure that its more technology advanced systems are operationally effective and operationally suitable for the missions required of them.

3. U.S. Versus Australia

Of a similar physical size but much larger population, the U.S. is an economic and military superpower compared to Australia. Table 2 compares some significant characteristics of the two nations.

TABLE 2: U.S. VS. AUSTRALIA 1991/92 [Ref. 10]

1991 Statistics	U.S.	Australia
Area	3,021,295 sq m	2,966,151 sq m
Population	251.8 million	17.1 million
GDP	$US 5,673.9 billion	$A 376.3 billion ($US 293.2 billion)
Growth	-0.8%	-2.2%
Inflation	4.3%	3.3%
Debt	$US 828.5 billion	$US 125.0 billion
Defence Budget % of Federal Outlay	$US 290.9 billion 22%	$A 9.44 billion ($US 7.27 billion) 9%
Total Armed Forces	1,913,750	67,900
Spending on Capital Equipment % of Defence Budget	$US 71.7 billion 26.4%	$A 1.92 billion ($US 1.40 billion) 20.4%
R & D Expenditure % of Defence Budget	$US 36.2 billion 12.4%	$A 0.22 billion ($US 0.16 billion) 2.3%

a. Differences

The "National Military Strategy of the United States" [Ref. 7] affirms that U.S. Defence policy is built upon four key foundations:

(1) Strategic Deterrence and Defence. The significant political instabilities in the former Soviet Union and the threat posed by the increasing numbers of potentially hostile states developing weapons of mass destruction requires that the maintenance of a modern, fully capable and reliable strategic deterrent remains the first defence priority.

(2) Forward Presence. The day to day presence of U.S. forces in regions vital to U.S. national interests is key to averting crises and preventing war. In addition to forces based overseas and afloat, forward presence includes periodic and rotational deployments, access and storage agreements, combined exercises, security and humanitarian assistance, port visits and military to military contacts.

(3) Crisis Response. The capability to respond to regional crises on short notice is a key demand of U.S. strategy. This response may range from a single discriminate strike to the employment of overwhelming force to defeat a regional aggressor.

(4) Force Reconstitution. Reconstitution is required to preserve a credible capability to forestall any potential adversary from competing militarily with the U.S. It involves forming, training and fielding new fighting units if required at short notice. It also involves maintaining technology, doctrine, training, experienced military personnel and innovation necessary to retain the competitive edge in decisive areas of potential military competition.

This strategy is founded on the premise that the United States will provide the leadership needed to promote global peace and security [Ref. 7:p. 6]. It

does, however, reflect the shift from containing the spread of communism and deterring Soviet aggression to a more diverse, flexible strategy which is regionally oriented and capable of responding decisively to future challenges [Ref. 7:p. 1]. Although the U.S. and Australian strategic policy elements may not be directly comparable, the U.S. places a greater emphasis on Defence with strategies of world leadership, global influence and self sufficiency, while Australia places emphasis on regional influence and self-reliance.

To achieve these goals, the U.S. devotes a considerably higher proportion of its Federal expenditure to Defence, than does Australia. It also spends a considerably greater percentage of its Defence Budget on R&D. U.S. policy is to maintain world leadership in key Defence technologies, by continuously improving the process of indentifying and introducing new technologies [Ref. 9]. Although R&D is conducted with emphasis on those areas unique to Australia, lower risk, proven technologies are preferred for the majority of new Australian Defence acquisitions.

b. Similarities

Like Australia, the U.S. current projections for FY 92-95 show a continued reduction of the Defence Budget by about 2% per annum. Additionally, with the recent change to a Democratic Administration under President Clinton, further reductions in Defence expenditure can be expected. During this period of budget and trade deficits and urgent domestic needs, the U.S. military strategy will be implemented within a significantly reduced Defence budget, and so places a premium on efficiency without compromising effectiveness [Ref. 7:p. 4].

As does Australia, the U.S. relies on technological superiority to offset quantitative disadvantages, to minimise risk to its forces, and to enhance deterrence and the potential for swift, decisive termination of conflict [Ref. 7:p. 10]. The U.S

also realises it can meet the challenges of the foreseeable future with a much smaller force than it has had in recent years [Ref. 7], and that implications of a 25% force cut by 1995 may be possible [Ref. 10]. Despite these funding and program cutbacks, the U.S. is also building new surface combatants and submarines. The first DDG-51 "Arleigh Burke" completed testing and the first SSN-21 "Seawolf" is under construction.

A significant similarity between the U.S. and Australia is one of culture. Both nations have predominantly caucasian, English speaking populations, a democratic system of government, close economic, military and political ties, and share similar cultural values and ideology.

Despite being significantly larger than Australia in economic and military terms, and, consequently, having a different Defence strategy, the U.S. is similar to Australia in many areas. These include reducing budgets and size of the Defence force, a requirement for advanced technology, and a need for efficiency while maintaining effectiveness. But perhaps above all, a similar culture which promotes a relative ease of communication and assimilation of ideas, concepts, procedures and methodologies between the two nations.

4. United States Navy Versus Royal Australian Navy

A similar contrast applies to the navies of both nations. As Table 3 shows, the USN is far larger and more capable than the RAN. However, there are number of similarities. Although the RAN had its origins in the Royal Navy and with British systems, since the 1960's the greater influence on the RAN has been from the USN. The purchase of three modified Charles F. Adams (DDG-2) class destroyers from the U.S. in the mid 1960's heralded an increasingly close relationship between the two navies. The purchase of four Oliver Hazard Perry (FFG-7) class frigates from the U.S. in the early 1980's, and the local construction of two more of the class in

Australia, continued this relationship. Although the RAN's needs no longer support the purchase of current U.S. ship types, many new systems and equipment are still purchased through the USN. Ongoing support for these U.S. ships currently in RAN service, and Australia's emphasis on interoperability with allies, ensure a continuing close association. The RAN shares with the USN much common equipment and weapons, compatible operational procedures, similar logistic support systems and defence acquisition procedures.

TABLE 3: USN VS. RAN 1991 [Ref. 10]

	USN	RAN
Personnel	546,650	15,300
Submarines	110	5
Aircraft Carriers	14	-
Cruisers	48	-
Destroyers	45	3
Frigates	83	8
Patrol (inc. Coast Guard)	30	15
Mine Warfare	24	2
Amphibious	65	1
Support & Misc.	162	12
Total Ships:	**581**	**46**
Major Ship Acquisition Programs	DDG-51 class destroyers SSN-21 class submarines	ANZAC class frigates COLLINS class subs.

D. OT&E BACKGROUND SUMMARY

OT&E forms a fundamental part of minimising risk in the weapons system acquisition process and in future system operations. It is conceptually different from DT&E, being focussed on assessing the operational effectiveness and operational

suitability of the system in a realistic combat environment, with respect to the user requirement.

Australia is placing emphasis on capital investment for Defence, particularly for the RAN, with new frigates and submarines presently under construction. In response to budget reductions the current focus of the RAN is towards a smaller and more technology oriented force, with a more streamlined and effective organisation.

The U.S. and Australia have a number of similarities, perhaps the most important, a similar culture which promotes a relative ease of communication and assimilation of ideas, concepts, procedures and methodologies between the two nations. The USN is a world leader in the development of high technology weapons systems and has extensive experience in their acquisition, testing and operation.

With new frigates and destroyers due to enter service in the mid 1990s, the RAN has an urgent need for an efficient, effective OT&E system to ensure the operational risk of these new combatants is minimised, and the combatants meet the current requirements of the RAN.

III. USN SHIP OPERATIONAL TEST AND EVALUATION

This chapter describes the USN OT&E system. It explains the OT&E relationship and importance to the U.S. Department of Defence (DoD) acquisition process, the specific OT&E policies and methods employed in ship OT&E and why the OT&E of ships is different from other systems. The USN system of ship acceptance and the input of OT&E into the process is also described. The OT&E of the DDG-51 class destroyer, the latest class of warship to undergo OT&E, is used as an example of the implementation of USN OT&E policies. The workings of the USN system are well documented and the OT&E system can be traced from the statute requirements of Congress, through DoD directives to implementation by Navy specific instructions.

A. U.S. DEPARTMENT OF DEFENCE ACQUISITION PROCESS

The USN OT&E system forms an integral part of the US DoD acquisition process. In 1987, the Defence system acquisition process underwent revision in an attempt to make it less costly, less time consuming, and more responsive to the needs of the operational community. The Defence system life cycle consists of five phases of the acquisition process:

- Concept Exploration/Definition
- Demonstration/Validation
- Engineering and Manufacturing Development
- Full Rate Production/Deployment
- Operational Support

As Figure 3 shows, these phases are separated by major decision points (milestones) when a program is reviewed and authorised to advance to the next stage in the cycle, that provide a basis for progressive decisionmaking associated with program maturation. T&E results and planned T&E play an important part and are rigorously assessed as part of the milestone reviews [Ref. 18:p. 1-3]. These milestones are:

- Milestone O - Concept Studies Approval
- Milestone 1 - Concept Demonstration Approval
- Milestone II - Development Approval
- Milestone IIA - Low Rate Initial Production
- Milestone III - Full Rate Production
- Milestone IV - Major Modification Approval (as required)

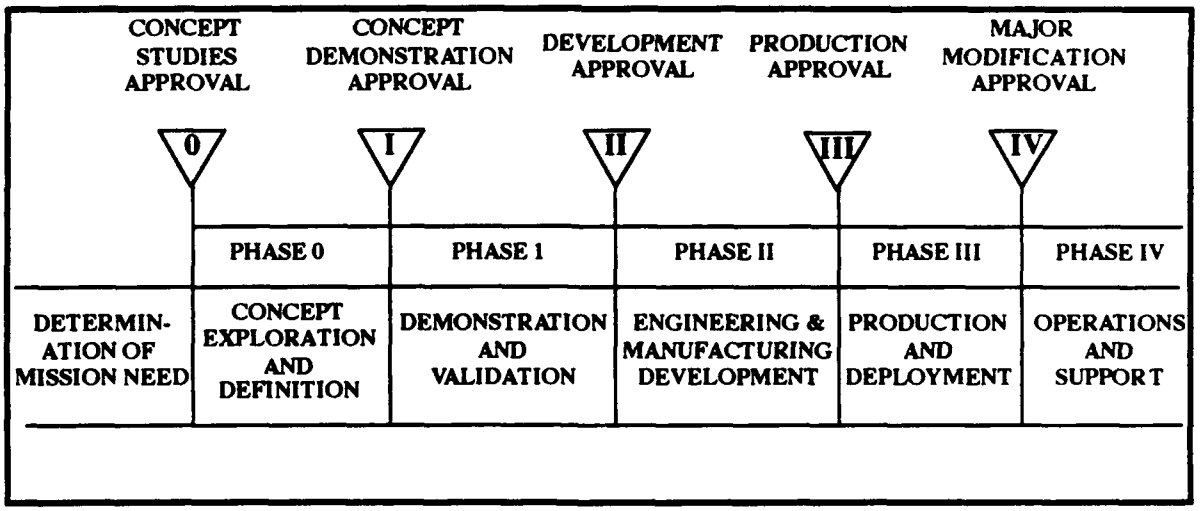

Figure 3: U.S. Acquisition Process for Major Programs

B. TYPES OF USN SHIP TEST AND EVALUATION

The USN Instruction on Test and Evaluation [Ref. 11] defines the principal types of T&E pertaining to ships as follows:

1. Developmental Test and Evaluation (DT&E)

DT&E is conducted to assist the engineering design and development process and to verify attainment of technical performance specifications and objectives [Ref. 11:p. 3]. DT&E is conducted in three major phases.

2. Production Acceptance Test and Evaluation (PAT&E)

PAT&E is testing conducted on production items to ensure systems meet contract specifications and requirements, and is a type of DT&E [Ref. 11:p. 5]. The USN regard trials of new ships conducted by the Board of Inspection and Survey (INSURV) and shipyard industrial testing at PAT&E [Ref. 32:p. 2-5]. Two phases of ship PAT&E are defined:

- Ship Construction Tests and Trials consist of all testing conducted on the ship during construction, including INSURV's Acceptance Trials.
- Ship Post-Delivery Tests and Trials are the conventional tests and trials, including INSURV's Final Contract Trials, that commence after ship delivery and continue to the end of the SCN obligation or work limiting date.

3. Operational Test and Evaluation (OT&E)

OT&E is conducted to determine a system's operational effectiveness and operational suitability, identify system deficiencies and the need for potential modifications to meet established OT thresholds, and develop tactics [Ref. 11:p. 5A]. OT&E has three distinguishing characteristics:

- It is conducted in an operationally representative environment.
- It is conducted on production representative equipment using fleet personnel for operation and maintenance.

- It is conducted against a threat-representative simulated enemy carrying out threat tactics per the latest threat assessment.

OT&E is subdivided into two major categories:

- Initial OT&E (IOT&E) (OT-I and OT-II) which is up to and including OPEVAL (final phase of OT-2).
- Follow-on OT&E (FOT&E) (OT-III and OT-IV) which is all OT&E after the final phase of OPEVAL.

C. OT&E IN THE ACQUISITION PROCESS

According to the Honorable Gerald A. Cann, Assistant Secretary of the Navy for Research, Development and Acquisition:

> Test and evaluation is the major control mechanism in the acquisition process for assessing system performance against system requirements. Navy decision makers rely on solid testing results, both developmental and operational, to provide the analytical groundwork for forming judicious program decisions. [Ref. 12]

This statement by the USN's senior acquisition executive, highlights the importance of T&E within the USN. Program advance from one phase to the next is not by the calendar of planned schedule, but by actual resolution of critical operational issues and achievement of pre-set thresholds verified by T&E [Ref. 11:p. 2]. The importance of OT&E, in particular, to the progressive assessment of programs is such that its use has been mandated by the U.S. Congress and incorporated into the laws of the United States.

1. Statute Requirement

The requirement for adequate OT&E of Defence programs has strong congressional support and is mandated by law. The law includes the provision of a Director of Operational Test and Evaluation in the Department of Defence,

appointed from civilian life by the President, by and with the advice and consent of the Senate [Ref. 16]. The law also addresses specific areas of OT&E reporting and conduct to ensure the Congress is kept informed, and the testing and reporting are impartial [Ref. 17]. By including the requirement that a major Defence acquisition program may not proceed beyond low-rate initial production (i.e. for Milestone III - Full Rate Production Decision) until Initial OT&E of the program is completed, Congress ensures that OT&E is an integral part of the acquisition process.

2. OT&E Contributions at Major Milestones

T&E progress is monitored by the Office of the Secretary of Defence (OSD) throughout the acquisition process. For major Defence acquisition programs, the Director, T&E and the Director, OT&E within OSD render independent assessments to the Defence Acquisition Board, the Defence Acquisition Executive and Secretary of Defence at each major milestone. These T&E officials also assess the T&E results for less than major defence acquisition programs that are specifically designated by OSD as OSD T&E Oversight Programs. The assessments are based on the following T&E information: [Ref. 18:p. 2-5]

- The Test & Evaluation Master Plan (TEMP) and more detailed supporting documents developed by responsible Service activities.
- Service operational test agency reports and briefings.
- Developmental test and evaluation data.

a. OT&E prior to Milestone I

During the Concept Exploration / Definition Phase prior to Milestone I, laboratory testing, modeling and simulations are conducted to demonstrate and assess the capabilities of key subsystems and components. The test and simulation designs are based on the requirements documented in the Mission Need Statement (MNS). The Operational Test and Evaluation Agency (OTA) monitors concept

exploration T&E to gather information for future test and evaluation planning and to provide effectiveness and suitability inputs desired by the Program Manager. The OTA also conducts operational assessments, as feasible, to assess the operational impact of candidate technical approaches and to assist in selecting preferred alternative systems concepts. [Ref. 18:p. 2-5]

b. OT&E prior to Milestone II

During the Demonstration/Validation phase prior to Milestone II, concepts approved for demonstration and validation form the baseline that is used for detailed test planning. The OTA conducts early operational assessments to identify the best approach, indicate the risks and solutions for this phase of development, examine operational aspects of the systems development, and estimate potential operational effectiveness and suitability. This OT&E phase is an assessment only, with no actual testing being conducted. Typical operational and support personnel are used to obtain a valid estimate of the user's capability to operate and maintain the system. The user of the system monitors test and evaluation during the concept Demonstration and Validation phase. Among the most important products of user monitoring are the attainment of early orientation and training, demonstrations of system performance and valid operational test assessments of systems maintainability and supportability.[Ref. 18:p. 2-7]

c. OT&E prior to Milestone III

The objective of the Engineering and Manufacturing Development (EMD) phase prior to Milestone III, is to design, fabricate and test a preproduction system that closely approximates the final product. T&E activities intensify during EMD, culminating in OPEVAL, and make significant contributions to the overall acquisition decision process. [Ref. 18:p. 2-9] OT&E conducted prior to the production decision is for the following reasons:

- Estimate the operational effectiveness and suitability of the system.
- Identify operational deficiencies.
- Recommend and evaluate changes in production configuration.
- Provide information for developing and refining logistics support requirements for the system and training, tactics, techniques, and doctrine.
- Provide information to refine operation and support cost estimates, and to identify system characteristics or deficiencies that can significantly impact these costs.
- Determine whether the technical publications and support equipment are adequate.
- Estimate the survivability of the system in the operational environment.

d. OT&E after the Production Decision

OT&E activities continue after the production decision in the form of Follow-on Operational Test and Evaluation (FOT&E) consisting of OT-III and OT-IV. It is accomplished to verify the operational effectiveness and suitability of the production system and to determine if deficiencies identified during initial OT&E (OT-III) have been corrected. A second phase of FOT&E (OT-IV) may be conduced by the user to refine doctrine, tactics, techniques and training programs over the life of the system. [Ref. 18:p. 2-10]

D. US OT&E ORGANISATION

Major participants in the US OT&E process are listed in Table 4. The US OT&E community consists of a mix of service and OSD offices responsible for planning, programming, budgeting and evaluating operational tests. Figure 4 gives an outline of the OT&E organisation.

TABLE 4: USN OT&E FUNCTIONAL AUTHORITIES

OT&E Function	USN Authority
Policy Maker & Overseer	Director, Operational Test & Evaluation (DoD)
Sponsor	Chief of Naval Operations
Developing Agency	Commander, Naval Sea Systems Command
Operational Tester & Evaluator	Commander, Operational Test & Evaluation Force
User	Fleet Commanders, Ships' Commanding Officers
Coordinator	Director, T&E and Technology Requirements

The US OT&E community consists of a mix of service and OSD offices responsible for planning, programming, budgeting and evaluating operational tests. Figure 4 gives an outline of the OT&E organisation.

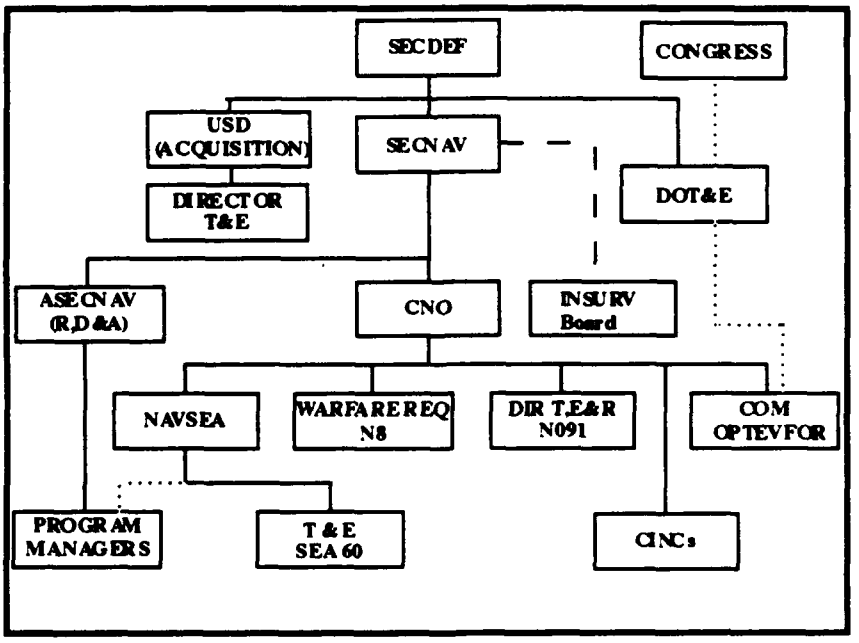

Figure 4: U.S. OT&E Organisation

1. Policy Maker and Overseer

The Director of OT& E (DOT&E) is the principal OT&E official in the Department of Defence and the principal advisor to the Secretary of Defence on OT&E. He is responsible for policy formulation, evaluation and oversight of OT&E within DoD. With status comparable to an Assistant Secretary of Defence, DOT&E is independent of other DoD officials and reports directly to the Secretary of Defence and additionally to Congress. His responsibilities include the following [Ref. 13:p. 7-4]:

- Monitoring and reviewing all OT&E within DoD.
- Designating observers to be present during preparation for and conduct of the testing portion of OT&E.
- Controlling joint OT&E and coordinating OT&E conducted by more than one Military Department or Defence Agency.
- Analysing the results of major system acquisition OT&E. For major systems and DOT&E oversight programs, reporting to SECDEF and to Congressional Armed Services and Appropriations Committees that OT&E is adequate and confirms effectiveness and suitability for combat systems tested.
- Making recommendations to SECDEF on all budgetary and financial matters pertaining to OT&E, including facilities and equipment.
- Approving OT&E plans for major Defence acquisition programs and DOT&E oversight programs.

The office of DOT&E was established because, although each of the Services have had their own OT&E agencies, Congress perceived that operational testing was not as objective as it should be. It wanted a layer of oversight over the procurement process, especially OT&E. As a result, DOT&E also has reporting requirements to Congress as well as the Secretary of Defence. [Ref. 19]

2. Sponsor

The Program Sponsor is responsible for acquisition program requirements and related system thresholds. The requirements are determined based on continuing assessments of current and projected capabilities in the context of changing military capabilities and national Defence policy. Within the USN, the Sponsor works for the Chief of Naval Operations (CNO). For major warship programs the sponsor is N8 - Warfare Requirements. Under the new USN organisation, increasing importance is given to the Fleet and Type Commanders in determining requirements and allocating priorities. Besides generating the user requirement, the Sponsor also has a review function in the OT&E process. [Ref. 20]

3. Developing Agency

When a program achieves Milestone 0, a program office is formed to manage the acquisition of the system. For ships and ship systems, this office may be established within the Naval Sea Systems Command (NAVSEA) or is affiliated with a Program Executive Officer, being 'double hatted', with responsibilities to both the Assistant Secretary of the Navy (Research, Development and Acquisition), and to NAVSEA. The program office is responsible for the conduct of DT&E in preparation for OT&E. To assist all NAVSEA programs with T&E matters, NAVSEA has established its own T&E office (SEA 60) whose purpose is to [Ref. 23]:

- Assist Program Managers in complying with policies and incorporating lessons learned of the past.
- Review T&E aspects of programs at major milestones
- Keep COMNAVSEA and PEOs appraised of overall posture of T&E.
- Influence OSD and Navy T&E policy.

Although primarily a DT&E policy authority, this office also has an input into the OT&E process by reviewing the TEMP, and by conducting OT&E readiness reviews of NAVSEA programs.

4. Operational Tester & Evaluator

The Operational Test and Evaluation Force (OPTEVFOR) is the USN's sole independent operational test agency responsible for the planning and conduct of OT&E. COMOPTEVFOR reports directly to the CNO, and is separate and distinct from the developing, procuring commands and the user. Results of OPTEVFOR evaluations are reported directly to CNO and to DOT&E. OPTEVFOR's mission is to test and evaluate weapons systems, ships aircraft, and equipment in the anticipated operational environment and against the anticipated threat: to develop and validate procedures and tactics employing these weapons systems, ships, aircraft and equipment: and when directed by the CNO, to assist developing agencies in the accomplishment of DT&E [Ref. 14:p. 1]. OPTEVFOR involvement in early phases of research and development includes inputs to the Test and Evaluation Master Plan (TEMP), observing development testing, and conducting those phases or operational testing necessary to provide CNO with an early and independent operational assessment [Ref. 13:p. 7-5].

5. User

The Commanding Officer and crew of the ship under test, and his Fleet and Type Commanders are the ultimate users of the system. The personal assessment of the Commanding Officer of the ship under test is sought by OPTEVFOR during the conduct of OT&E [Ref. 15:p. 44].

6. Coordinator

CNO has responsibility for ensuring the adequacy of the Navy's overall test and evaluation program. T&E policy and guidance are exercised through the Director, Test, Evaluation and Technology Requirements (N091). This organisation also acts as a T&E Focal Point and Coordinator, responsible for coordination of T&E matters in the designated Programs, System Commands and Department of the Navy. [Ref. 13:p. 7-5]

E. USN OT&E POLICY

USN OT&E policy has its basis in the statutes approved by Congress. This policy is refined in the DoD acquisition Directive 5000.1[Ref. 25] and DoD Instruction 5000.2 [Ref. 24]. The essential T&E elements in these directives are then further detailed in OPNAV Instruction 3960.10C [Ref. 11] and other subordinate instructions. This hierarchy of documentation establishes the disciplined management approach to OT&E taken by the USN.

Basically, USN test and evaluation programs are structured to [Ref. 24:p. 8-2].

- Provide essential information for assessment of acquisition risk and for decision making.
- Verify attainment of technical performance specifications and objectives.
- Verify that systems are operationally effective and suitable for intended use.
- Provide essential information in support of decision making.

OT&E programs, in particular, are structured to determine the operational effectiveness and suitability of a system under realistic combat conditions and to determine if the minimum acceptable operational performance requirements as specified in the Operational Requirements Document have been satisfied. U.S. OT&E policy requires[Ref. 24:p. 8-5]:

- Threat representative forces be used whenever possible.
- Typical users to operate and maintain the system under conditions simulating both combat stress and peacetime conditions.
- Production or production representative articles be used for the dedicated phase of OT&E that supports the full rate production decision.

The ultimate uses of information obtained through OT&E are feedback to the Developing Agency on the operational strengths and weaknesses of the system, and inputs for decisions to proceed with production and fleet introductions. A number of key factors of note are highlighted in USN OT&E policy:

1. Independence

The fundamental DoD Directive on Defence acquisition [Ref. 25:p. 1-8] requires an independent operational test activity. Each Military Department is required to establish an independent operational test and evaluation activity. This activity is required to:

- Be separate and independent from the materiel-developing and procuring agency and the using agency.
- Be responsible for planning and conducting operational tests, reporting results, and providing evaluations of each tested system's operational effectiveness and suitability.
- Report directly to the head of the DoD Component, except that the Secretary of a Military Department may delegate responsibility for supervising this activity to the Service Chief concerned.

Acquisition managers are not to influence or attempt to influence the objectivity and completeness of test results presented to decisionmakers by the independent operational test activity. Independence is necessary so that there is no question of impropriety. The testing and reporting agency has nothing to gain or lose by whatever they say. As major acquisition decisions hinge on the results of OT&E,

independence is necessary to ensure that the reports on which those decisions are based are not self serving. [Ref. 19]

2. Use of Contractors

The use of system contractors in support of OT&E conducted to support a decision to proceed beyond low rate initial production (Milestone III) is restricted by law [Ref. 17] to ensure impartiality of testing. No person employed by the contractor for the system being tested may be involved in OT&E, unless contractors are planned to be involved when the system is deployed in combat.

3. T&E Planning

Test and evaluation planning is considered by the USN to be fundamental to the conduct of OT&E. The Test and Evaluation Master Plan (TEMP) is the controlling T&E document and is considered by some to be the single most important document associated with an acquisition program. The TEMP is directive in nature and defines and integrates test objectives, critical issues, system characteristics, test responsibilities resource requirements and test schedules. An approved TEMP constitutes direction to conduct the specified T&E.[Ref. 15:p. 6-1]

Drafted by the Program Manager (PM), the TEMP's main purpose is to combine the PM's DT&E and COMOPTEVFOR's OT&E into one integrated master plan. [Ref. 11:p. 11] OPTEVFOR draft Part Four on OT&E and provide OT&E resource requirements for Part Five. The TEMP is then co-submitted by both the Program Manager and COMOPTEVFOR. For ship programs, the TEMP is reviewed by the Assistant Chief of Naval Operations (Surface Warfare), the Director, T&E and Technology Requirements, and the Assistant Secretary of the Navy (Research, Development and Acquisition). The TEMP is ultimately approved at the DoD level by the Director, OT&E and the Under Secretary of Defence for Acquisition, Director Test and Evaluation.

Approval of the TEMP constitutes establishment of a contract between the requirement-setter and the PM which is essential to formal and accountable program execution, and between the requirement-setter and the OT agency, upon which COMOPTEVFOR will independently evaluate system operational effectiveness and suitability. An approved TEMP is required at Milestone I and is updated for each subsequent milestone and when significant program changes occur. The TEMP also serves several secondary purposes:

- It allows all involved to see exactly what hurdles the system must clear.
- It allows the PM to make good projections of COMOPTEVFOR's OT&E costs, which must be funded.
- It allows fleet, range, simulator and target schedulers to plan for the required services.

4. Combined DT&E and OT&E

The USN has a policy that combined DT&E and OT&E testing should only be considered when there are time and cost savings [Ref. 24:p. 8-3]. However, this combined approach must not compromise either the developmental or operational test objectives. Also a final independent phase of operational testing and evaluation, termed "OPEVAL", is required for beyond low rate initial production decisions [Ref. 24:p. 8-4].

"Combined testing" refers to a single test program conducted to support both DT&E and OT&E objectives. The advantages of combined testing are the shorter time required for testing, and cost savings by eliminating redundant activities. These need to be weighed against the limitations of the additional extensive coordination required and the less than optimum environment and coverage for OT&E that may occur. Early involvement of OT&E personnel during system development increases their familiarity with the system and permits identification of operational concerns early in the program.

The U.S. has extensive experience with combined testing, some successful and some unsuccessful, and they conclude that it is possible to have combined test teams involved throughout the testing process. The DT&E and OT&E teams can share mutually beneficial data, as long as the test program is carefully planned, evaluated and reporting activities are conducted separately. [Ref. 18:pp. 17-1 - 17-4].

5. Modeling and Simulation

DoD directives encourage the use of simulation and modeling to assist in projecting operational effectiveness and operational suitability prior to Milestone II, but limit their use in subsequent OT&E to that of supplementing OT&E test data. The use of modeling and simulation can increase the efficiency of the T&E process, reduce the time and cost, provide otherwise unattainable and unmeasureable data, and provide more timely and valid results. Although simulations are not a substitute for live testing, USN OT&E policy recognises that it is useful to augment tests by simulating non-testable events and scenarios, and for overcoming resource limitations. Simulation can also be used to extend test results, to improve the statistical sample, or to determine overlooked or directly unmeasured parameters. [Ref. 18:pp. 16-1 - 16-8]

6. Foreign Weapons Evaluation

The US DoD has a foreign weapons evaluation program which is designed to support the evaluation of a foreign nation's weapons system, equipment or technology in terms of its potential to meet a specific U.S. military requirement. The primary objective of the program is to reduce the costs of U.S. research and development, while leading to the acquisition of foreign equipment for U.S. use [Ref. 18:p. 21-1]. From the OT&E viewpoint, the USN 'try-before-buy policy' is still maintained, despite the early phases of OT being unable to be achieved.

COMOPTEVFOR may be directed to assess the adequacy of any previously conducted OT&E and to provide recommendations on the need for additional U.S. T&E prior to procurement [Ref. 27:p. 6]. Obtaining pertinent test and evaluation data from foreign governments and manufacturers is necessary to preclude duplication and reduce costs.

7. OT&E Funding

Congress mandates that the costs of initial OT&E required to achieve a full production decision shall be paid from funds available for the system being tested [Ref. 17]. Funding associated with T&E (including instrumentation, targets and simulations) are identified in the system acquisition cost estimates, acquisition plans and the TEMP [Ref. 18:p. 18-11]. The Program Manager plans, programs, budgets and funds the costs of all resources identified in the approved TEMP for all T&E through OT-III. OPTEVFOR estimates the costs to conduct OT&E and the program manager budgets and funds these costs. OT&E costs include test articles, expendables, targets, data collection and reduction and OPTEVFOR program related costs. The Program Manager does not fund fleet operating costs for T&E support, which includes fuel and aircraft, The operating costs for OT-II and III, and all costs for OT-IV, except procurement costs and OPTEVFOR costs, are funded by the Fleet CINCs.[Ref. 11:p. 21] OPTEVFOR internal man-hours, and computer hours actually expended are not charged to individual programs.

8. Land Based Test Sites

A Land Based Test Site (LBTS) is a facility that duplicates, simulates or stimulates the employment of a system's planned operational installation and utilization, primarily for the purpose of conducting DT&E. LBTS are often used to test system integration and overall performance.[Ref. 11:p. 12] COMOPTEVFOR advises the CNO on the adequacy of LBTS for the conduct of OT&E. LBTS test data

is normally used to support Milestone IIA decisions and not the more stringent Milestone III. Except where approved by CNO, OT&E intended to support production decisions will be performed in the operational environment in preference to the LBTS.

9. Ship OT&E

a. But Ships are Different

The accomplishment of ship T&E varies considerably from the normal test cycle due to the lengthy period for design, engineering and construction of a major ship, and because ship T&E includes both that conducted on the ship platform itself, as well as that conducted on the equipment and systems to be installed on the ship.

Ship acquisitions are low volume, high cost programs, and so, while subject to the same basic DoD and USN T&E policies applied to other systems, their procurement requires special T&E processes. If ships were procured the way other Navy systems are, the lead ship of the class would be used as a prototype for conducting T&E prior to approving the construction of the follow-on ships. Because of the time associated with the design and construction of a ship and the fact that few technical or operational risks are associated with the ship platform itself, the prototyping approach in not necessary.

In a typical ship acquisition program, it can take about five years between the contract award for the lead ship and the time the ship is itself ready to conduct at-sea operational testing. To delay the construction of the follow-on ships would have a significant impact on the shipbuilding program's costs and schedule. This longer schedule would substantially increase shipyard costs in return for a negligible reduction in the risk of the ship not meeting operational requirements. A significant time lag between the production of the lead and follow-on ships would

force a shipbuilder to let most of his experienced workers go and rehire and retrain others when construction resumed. Moreover, the significant cost savings available through quantity procurement of many of the ships' equipments would not be realised if there was a time lag in production between the lead and follow-on ships.[Ref. 29] Also, from a contracting standpoint, a significant amount of lead time is required so that equipment will be available when needed for construction. Much of the long lead equipment is contracted before there is a ship available to test.[Ref. 19]

b. Policies and Principles

Congress accepted these practicalities of ship OT&E and amended the law to recognise the special case of ship OT&E [Ref. 30]. Because the development and construction period for a major ship normally precludes completion of initial OT&E on the lead ship prior to the production decision for follow-on ships, successive phases of IOT&E are accomplished as soon as practicable to reduce risk and minimise the need for modification to follow-on units.

(1) The OT-I phase is an Early Operational Assessment (EOA) and is an evaluation of technologies, of processes, of plans and procedures, and design details to see if there any high risk areas that have a potential to cause cost overruns or degrade performance.

(2) The OT-II phase for a shipbuilding program is an extension of this concept, except that it occurs in a time frame where landbased testing facilities or mock-ups of sections exist. Operability and suitability can be assessed, though not necessarily on a production representative item.

Ship acquisition programs, therefore, usually have IOT&E between Milestones II and III, which consist of individual weapon systems testing and

system integration at land based test sites. A total ship OPEVAL is impractical in all cases except programs where a lead ship is constructed as an R&D effort involving a major technological advance in hull or machinery design [Ref. 28].

F. SHIP ACCEPTANCE

1. Policy

The purpose of ship acceptance in the USN is to ensure delivery to the Fleet of complete ships, free from both contractor and government responsible deficiencies [Ref. 35:p. 1]. Ship acceptance has traditionally been based only on the successful completion of PAT&E and material inspections, and for the first of class, has culminated in approval for Fleet Introduction. However, with the treatment of ships as complete systems, as for the DDG-51, Fleet Introduction was based also on OT&E results.

2. Definitions

Reference 35 provides the major definitions for the acceptance process:

- "Acceptance" is defined as the legal act of accepting custody of a new construction ship by the Navy upon delivery of the ship by a private builder.
- "Delivery" is defined as the actual assumption of custody by the Navy incident to acceptance. The date of delivery from a private shipyard is also the date of acceptance.
- "Fleet Introduction" is more a concept than a specifically defined milestone[1]. It signifies approval by the Secretary of the Navy that a ship class meets the operational effectiveness, operational suitability, safety and material standards for service use.

1. Conversation between Captain Tobin, USN, Surface Division, Board of Inspection and Survey, and the author, 27 October, 1992.

3. Responsibilities

Independent verification of readiness of ships for acceptance is the responsibility of the President, Board of Inspection and Survey (PREINSURV) who conducts Acceptance Trials and Final Contract Trials for each individual new ship [Ref. 11:p. 10]. Based upon its findings, the Board recommends acceptance or final settlement of the contract. The Board identifies material conditions which represent departures from the General Specifications and deficiencies that substantially reduce the ship's fitness for naval service and/or degrade its ability to perform its primary mission. [Ref. 34:p. 1] These deficiencies are noted in the Ship's Log, but may not necessarily be corrected.

A ship is normally accepted by the Commander, Naval Sea Systems Command. The preparation and presentation of a ship for acceptance trials is the responsibility of the Supervising Authority, normally the Supervisor of Shipbuilding (SUPSHIPS). Users also have a say in the acceptance process. A ship's prospective Commanding Officer submits progress reports and can request changes be made which are essential to safety or the ship's mission. The Type Commander monitors the construction and acceptance process to ensure "customer" input is provided, conducts a pre-commissioning habitability inspection and makes an acceptance recommendation to the Fleet Commander who, in turn, makes his recommendation on the request to deliver the ship. [Ref. 35:pp. 2 - 6]

4. Procedure

The procedure for ship acceptance and introduction to the Fleet is outlined in Figure 5. The Total Ship Test Program outlines two phases of this process [Ref. 32:p. 2-6]:

- Ship Construction Tests and Trials consisting of all testing conducted during construction, including Acceptance Trials.

- Ship Post-Delivery Test and Trials include final contract trials that commence after ship delivery and continue to the end of the ship construction obligation.

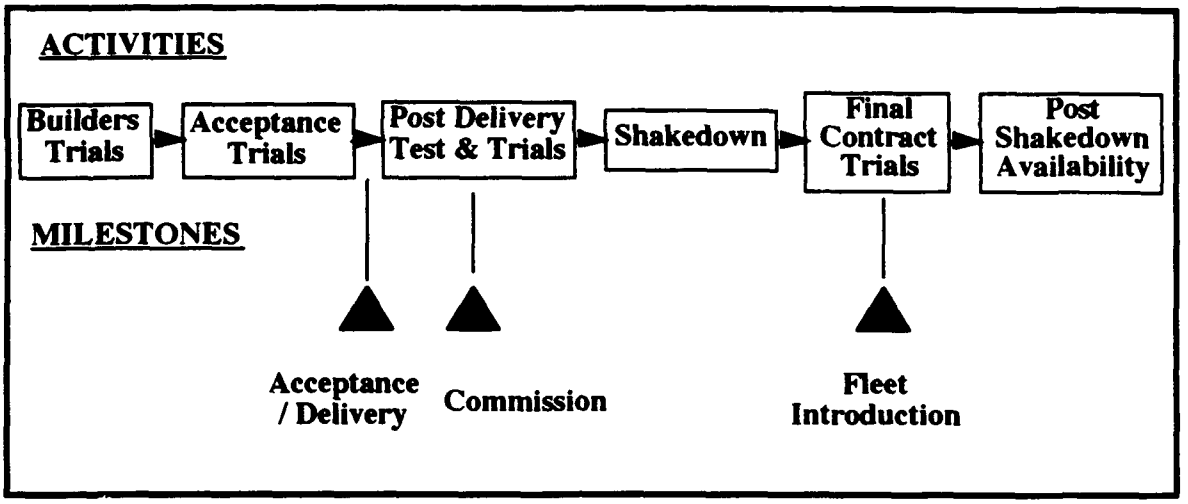

Figure 5: Traditional Ship Acceptance Schedule and Milestones

This procedure includes the following activities and milestones:

a. Delivery / Acceptance

Acceptance Trials are conducted by the INSURV Board when all work has been completed. These trials are conducted at sea and in port when the following prerequisites are met [Ref. 35:p. 11]:

- Successful completion of builders trials.
- All installed equipment operable and capable of meeting performance specifications.
- Habitability items complete.
- Completion of surveys not requiring remote ranges.
- Installation and checkout tests completed.

- All applicable naval certifications completed.
- Completed test reports and certifications available for inspection by the Trial Board.

On successful trial completion, and on the recommendation of PREINSURV, COMNAVSEA accepts the ship on behalf of the USN from the contractor.

b. Final Contract Trials

Final Contract Trials are trials and materiel inspections conducted at sea and in port by the INSURV Board to determine if builder responsible equipments are operating satisfactorily [Ref. 35:p. E3]. It involves operation of all combat systems, and the propulsion system at full power. On completion, PREINSURV submits a technical assessment of readiness for OT&E to CNO, and to COMOPTEVFOR when tasked by CNO [Ref. 11:p. 10].

c. Fleet Introduction

The successful completion of Final Contract Trials on the first ship of the class traditionally results in a recommendation for Fleet Introduction by PREINSURV to CNO. The Secretary of the Navy then approves Fleet Introduction of the ship class on the recommendation of CNO. In contrast, Fleet Introduction of systems is traditionally recommended by OPTEVFOR after successful completion of OT&E. However, for the DDG-51 class, where the ship was viewed as a complete system, Fleet Introduction was recommended by both PREINSURV and OPTEVFOR[2]after the completion of OT&E. Figure 6 show the acceptance and schedule milestones used for DDG-51.

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2. Conversation with Commander J. Kren, USN, OPTEVFOR, and the author 29 October, 1992.

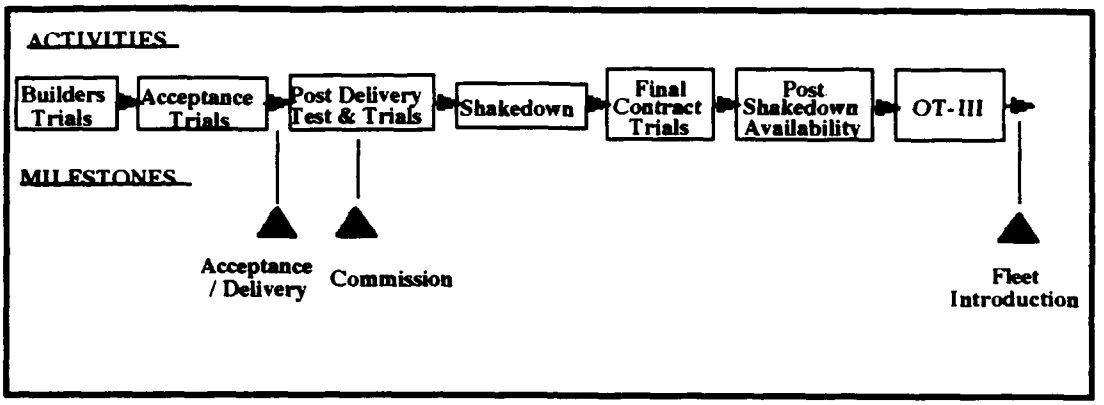

Figure 6: DDG-51 Ship Acceptance Schedule and Milestones

5. Ship Acceptance and OT&E

OT&E has traditionally not had an input into the ship acceptance process in the USN, with no involvement in Delivery, Acceptance or Fleet Introduction. It primarily focussed on the ship's systems rather than the ship as a whole, and was fundamental to the Fleet Introduction of these systems. With the view of the DDG-51 as a complete system, successful completion of OT&E is now a prerequisite for the Fleet Introduction of all new warship classes.

G. USN OT&E PROCEDURES

Procedures are the methodology by which policy is carried out. This section discusses the procedures adopted by the USN in implementing OT&E policy.

1. From the User Requirement to the OT&E Test Plan

The determination of the level and extent of OT&E required is a difficult question. For their multiwarfare capable ships, the USN focuses on the mission warfare areas to determine what is appropriate [Ref. 19]. The fundamental

cornerstone of OT&E is the user requirement, generated through a series of documents built into the acquisition process. The procedure involves progression through the following documents (Figure 7):

- Mission Need Statement (MNS)
- Cost And Operational Effectiveness Analysis (COEA)
- Operational Requirements Document (ORD)
- Top Level Requirement (TLR)
- Test and Evaluation Master Plan (TEMP)
- OT&E Test Plan (OT&E TP)

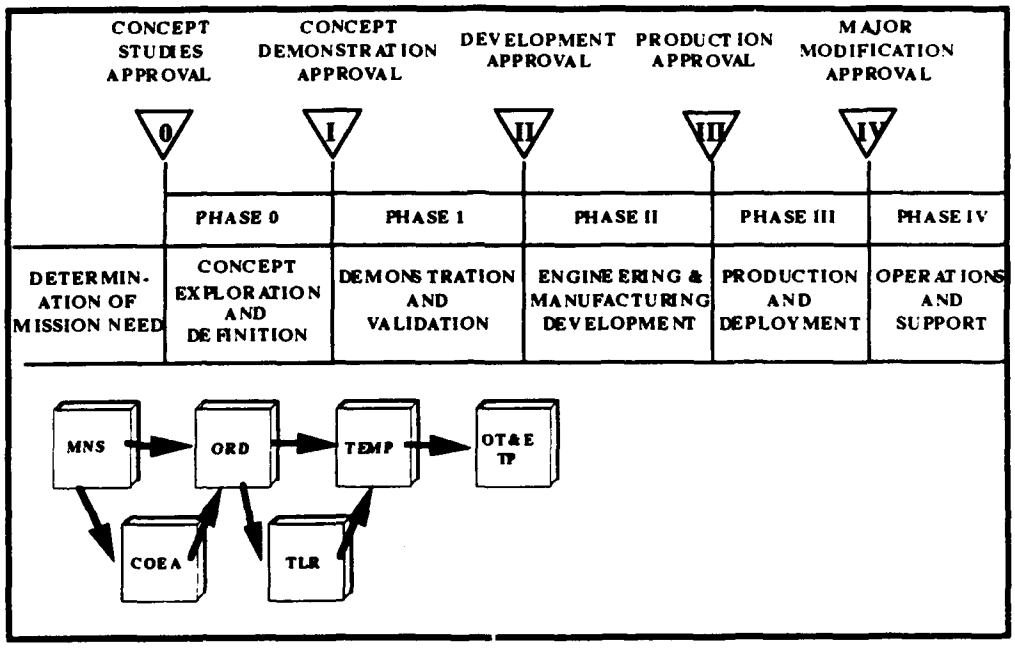

Figure 7: Progressive Definition of OT&E Documentation

a. Mission Need Statement

Acquisition programs are based on identified mission needs that are generated as a direct result of continuing assessments of current and projected capabilities in the context of changing military threats and Defence policy. A broad statement of mission need, expressed in terms of an operational capability, not a system-specific solution, is identified in a Mission Need Statement (MNS). [Ref. 24:p. 3-2]

b. Cost and Operational Effectiveness Analysis

A cost and operational effectiveness analysis (COEA) may be undertaken to evaluate the costs and benefits of alternative courses of action to satisfy the requirements of the MNS. The COEA looks at other alternatives e.g., are a lot of little ships or a few big ships needed to do the mission? The most suitable alternative is selected, e.g., a lot of little ships are required, and they need to do these things. It also develops the Measures of Effectiveness (MOE) for assessing the operational effectiveness of the alternatives.

c. Operational Requirements Document

From the MNS and COEA is developed the Operational Requirements Document (ORD) that contains the performance (operational effectiveness and operational suitability) and related operational parameters for the proposed concept or system. It contains the system performance objectives and minimum acceptable requirements to meet the requirements of the MNS. The MOEs used in the ORD and the technical parameters, are designed to support those same MOEs that were developed in the COEA [Ref. 19].

d. Top Level Requirement

For some ship acquisition programs, Top Level Requirements are prepared after the MNS and ORD. This is necessary because of the length and complexity of the ship design process. The TLR states the high level requirements for the ship. For example, the TLR for the DDG-51, Section 2.11a Operational Directions, under Mission, Warfare Areas states:

> Simultaneous action in Strike Warfare, Antisubmarine Warfare, Antisurface Warfare and Antiair Warfare required. The combat system shall provide for rapid, accurate and efficient employment of the ship's weapons.

e. Test and Evaluation Master Plan

The TEMP is developed from the ORD, and TLR if produced, and is the controlling T&E document that defines and integrates the test objectives, and Critical Operational Issues (COI) based on the ORD. For example, the DDG-51 TEMP [Ref. 31:p. IV-2] highlights the COI of Combat System Performance as follows:

> Will the combat systems support simultaneous action against threats in Antiair Warfare (AAW), Antisubmarine Warfare (ASW), Antisurface Warfare (ASUW), and Strike Warfare (STW) missions during independent or combined operations as a unit of a Battlegroup, Surface Action Group, Underway Replenishment Group or Amphibious Task Force?

This COI is addressed as a specific objective for OT-IIIA [Ref. 31:p. IV-11] which is to:

> Determine the capability of the integrated DDG-51 combat system to detect, track, localise and engage threat representative targets in a multiwarfare environment (STW, ASW, ASU and AAW).

From this specific objective, a test procedure is outlined by OPTEVFOR. The level and extent of testing is based on the level of confidence to be assessed. It is usually a compromise between the extent of testing and funding available, agreed between the PM and OPTEVFOR with DOT&E oversight. The TEMP is viewed as a contract between the Developer, the Sponsor, OPTEVFOR and OSD, through DOT&E, as what is committed to be done and funding is available. Any change to the TEMP must be approved by all signatories. The TEMP identifies limitations to the scope of testing which may include threat replicators e.g., when a MIG-29 threat aircraft is needed during testing, but an F-14 will be used. [Ref. 19]

f. OT&E Test Plan

This specific objective is then followed through to the OT&E Test Plan, developed by COMOPTEVFOR. The test plan contains "E" tests that assess operational effectiveness and "S" tests that assess operational suitability.The test plan then addresses how this will be done, by breaking it down into more specifics. AAW, EW, CAP, CIWS. Under DDG Test E-1 Combat System Performance, the Test Plan states:

> To determine the capability of the integrated DDG-51 combat system to detect, track, localize and engage threat representative targets in a multiwarfare environment (STW, ASW, ASU and AAW).

g. Summary

A requirement can, therefore, be traced from the mission need to the ORD, through to a COI and specific a objective in the TEMP, to the test plan and ultimately to the final OT&E report by OPTEVFOR. This linkage from mission need to operational test program defines the scope of testing. If a ship has a number

of mission areas and there are MOEs to evaluate the performance in those mission areas, then a test program is developed around those MOEs.

2. Assessment of Operational Effectiveness

In assessing operational effectiveness, OPTEVFOR examines each COI and related operational effectiveness objective, and decides what needs to be known to enable each objective to be assessed [Ref. 15:p. 9-1]. For example, the objective may be "to determine the sonar's capability to detect, classify, and track... in the natural acoustic environment." OPTEVFOR may decide the following measures of effectiveness are needed to assess the overall objective:

- Probability of detection
- Detection range
- Probability of correct classification given detection
- Probability of classifying a threat as a nonthreat
- Time between detection and classification
- Classification Range
- Probability of establishing a track, given detection
- Time between detection and track establishment
- Range at track establishment
- Percent of time tracks are held

They ensure that the appropriate environments, threats, etc., are included and that sufficient data will be generated to address the COI and objectives. OPTEVFOR initially determines the requirements and resources necessary to conduct the test. This is achieved by making a list of environments and other conditions under which the system will operate, and associating them with the various threats. This can be achieved by constructing a test design matrix of which Table 5 is an example.

TABLE 5: SAMPLE TEST DESIGN MATRIX [Ref. 15:p. H-2]

THREAT	GROUP CHAR	TEST TARGET	BENIGN ECM	ECM (SOJ/SSJ)	CHAFF (SRBOC)	SEASTATE (1-2)	MULTI TARGET	TOTAL MISSILE
I II	SEASKIM (<10m) SUBSONIC	MOD BQM-34S	A B	C	C	ABC	B	3
I IV	10-60m SUBSONIC	BQM-34S	J		E	EJ		2
III	<30m SUPERSONIC	MOD MQM-8G		D	D	D		1
III VI	30-60m SUPERSONIC	MQM-8G	H		F	FH		2
III VI	60-300m SUPERSONIC	MQM-8G						0
III	25-50DEG DIVE SUPERSONIC	MQM-8G						0
I	10-60m SUBSONIC	QF-86		G		G		1
II	SURFACE	QST-35		I				1

The letters indicate missile firing runs in alphabetical order of priority. The columns are the environment in which the firing is scheduled. [Ref. 15:p. H-1] Then the actual resources available are reviewed to determine which test objectives must be eliminated due to lack of funding.

Even though the operational test program is linked to mission need through the COEA, ORD and TEMP, there are a number of difficulties in developing appropriate OT&E tests. Many operational requirements are not very specific, meaning the testing and subsequent assessment of those requirements may be very subjective, and critical definitions need to be agreed before testing commences.

a. Qualitative Vs. Quantitative Assessment

The broad scope of many operational requirements makes their testing and subsequent assessment rather subjective, making the determination of meaningful and assessable quantitative MOEs difficult. Also a lack of resources may reduce an objective, quantitative, and statistically relevant test schedule to a more subjective, qualitative assessment. These situations require expertise and judgement, and compromise between the authorities involved, to make the tests as objective as possible. As an example, an antisurface warfare mission may require the ability to sink another ship, but the test program does not include this provision.

The test program has to be designed so that it will provide confidence that the ability can be demonstrated without actually sinking a ship. Similar situations are encountered in all the warfare areas, and additionally with ship survivability. One objective is to achieve statistical relevance. DOT&E works closely with the USN to help determine how many test assets are required to achieve a certain degree of confidence that a test objective has been met. A test may need to be repeated a number of times to gain statistical relevance. However, if this is not possible, or the direct proving of an ability is not possible (as in the surface warfare example), then the test needs to be designed so that what is observed in the test program is projected to be what would be observed in reality.

OPTEVFOR indicates the statistical significance of a result as follows:

- "Determine" means a statistically significantly result with a specified level of confidence.
- "Assess" means to qualitatively evaluate which will not achieve a statistically significantly result.

b. Definition Agreement

Another difficulty in assessing operational effectiveness is in defining the meaning of the requirement and the measures of effectiveness. This is particularly applicable to whole ship testing which may incorporate a specific equipment requirement in addition to an overall ship requirement. For example, the definition of a "Detection Opportunity" for a sonar, may differ from what is an ASW "Detection Opportunity" for the ship, given the other ASW related sensors that may be available. Agreement between authorities and the MNS is required for the whole ship versus individual systems. [Ref. 21]

3. Assessment of Operational Suitability

The assessment of operational suitability in the USN is more standardised than for the assessment of operational effectiveness. OPTEVFOR identifies 14 suitability issues for which they have standard suitability tests [Ref. 15:p. 9-4 - 9-8]:

- Reliability
- Maintainability
- Availability
- Logistic supportability
- Compatibility
- Interoperability
- Training
- Human factors
- Safety
- Documentation
- Transportability
- Wartime usage rates
- Manning
- Software supportability

Software supportability has only recently been added by OPTEVFOR. It relates particularly to totally intensive computer systems, termed "software intensive systems". It determines if a program manager has established adequate software support for his system.[Ref. 21] Not all these suitability issues need be addressed for a particular system. The nature and use of the system, and the phase of OT&E will determine the issues to be assessed.

a. Suitability Assessment Procedure

Early in the acquisition program, OPTEVFOR reviews the Integrated Logistic Support Plan (ILSP) against the ORD. The ILSP is a key acquisition document which defines the various methods used to provide the required range of logistic support for the system.Following ILSP review, OPTEVFOR determines the suitability tests required based on expected reliability, degree of confidence, thresholds, etc. required to be achieved. These determine the scope and length of the assessment. An onboard assessment at sea is conducted, during which questionnaires of crew members may be used and maintainability demonstrations are performed, usually using pre-faulted modules. Reliability, maintainability and availability (RM&A) data is collected and sent to the normal inservice analyst of RM&A data, the Naval Weapons Analysis Centre (NWAC) for analysis. In later OT&E, OPTEVFOR also uses data from the inservice maintenance management system (3M) and the individual system logs.[Ref. 21]

Not only does OPTEVFOR have specialist analysts for effectiveness issues, it also has suitability analysts who design tests and determine measures of suitability. They also evaluate and analyse the adequacy of logistic supportability. OPTEVFOR also relies on operational personnel to use their experience and knowledge of the system to identify inadequate logistic support.

4. OT&E Reporting

a. Reporting by COMOPTEVFOR

COMOPTEVFOR's evaluation report provides the CNO with conclusions regarding a system's operational effectiveness and operational suitability, and his recommendations regarding the systems future, i.e., fleet introduction, further development, additional OT&E, etc. The report also contains the test results and evaluation criteria to substantiate the conclusions and recommendations. [Ref. 15:p. 12-1] A report covers a complete OT&E phase (e.g., OT-IIA), relating the test results to the COIs and addressing the objectives stated in the TEMP. COMOPTEVFOR requests comments from the Commanding Officer of the ship under test ship. These comments are sent only to OPTEVFOR. All operational test data is considered to be the owned by OPTEVFOR until the final report is signed. Quick-look and interim reports are usually sent only if the testing could not be completed or when directed by the CNO. Although the final report may be a surprise to other authorities, the USN appears to favor this reporting procedure to ensure that:

- the conduct of OT&E remains impartial and is not influenced by the program manager or contractors during testing and analysis.
- OPTEVFOR's conclusions are based on a complete and thorough analysis.
- OT&E results and analysis are reported through one authority only.

b. Reporting by DOT&E

The reports rendered by DOT&E address whether the OT&E performed was adequate and whether the OT&E results confirm that the system actually tested is operationally effective and operationally suitable. In the past it used OPTEVFOR reports as basis and provided their own judgement. Following General Accounting Office (GAO) criticism that DOT&E overall assessments

consistently presented a more favorable presentation to the Congress of test adequacy and system performance than was warranted by the facts [Ref. 36:p. 31], it now does an independent analysis from the raw test data collected by OPTEVFOR. As DOT&E does not have any specialist analysis staff, it hires an independent contractor who works exclusively for DOT&E, to do the analysis. Experienced operators at DOT&E then make the assessment. DOT&E's written report to Congress is based now on OPTEVFOR reports and its own independent analysis.[Ref. 21]

5. OT&E Coordination

The USN recognises the importance of coordination between authorities in the successful achievement of T&E. The USN T&E coordinator is responsible to the Director, Test, Evaluation and Technology Requirements (N091). He is essentially the OPNAV area coordinator for Navy T&E, providing a primary contact point for all parties and setting up T&E briefings and meetings. His responsibilities include the chairmanship of the Test and Evaluation Coordination Group (TECG) for each major program.[Ref. 37] TECGs are used for complex, multifaceted programs which require extensive T&E coordination. Membership of a TECG includes the Program Manager, the Sponsor, COMOPTEVFOR, a logistics coordinator and others as appropriate (such as a PREINSURV representative). TECG recommendations are considered for inclusion in the TEMP.[Ref. 11:p. 15] Some of the functions of a TECG are the early definition of terms, measures of effectiveness and how these are to be measured, and the criteria for acceptable or not acceptable. Of note is the formation of a TECG does not imply a joint test team approach. Each T&E agency remains fully and solely responsible for conducting and reporting the types and phases of T&E for which it is accountable.

6. OT&E Personnel Selection and Training

OT&E is a specialised discipline, with its own philosophy and methodology. The U.S. community involved with ship OT&E select and train their military personnel. Although some personnel may develop into OT&E specialists, no career path in OT&E is consciously provided, and no naval personnel currently serving in DOT&E have served previously in OPTEVFOR.

a. OPTEVFOR

There are no special selection requirements for detailing military personnel for service as Test Directors in OPTEVFOR, although broad ship operations experience and combat system knowledge are preferred. OPTEVFOR is functionally organised along warfare lines, so specialists in each warfare area are preferred. Most Test Directors are of Commander rank, reporting to Captain level section heads. For particular programs, OPTEVFOR makes use of subject area experts, either resident or borrowed from a non-interested party. OPTEVFOR conducts an intensive four day Operational Test Directors (OTD) course covering the major areas of OT&E. Further details of this course are included in Appendix A. They also run adhoc segment courses which provide acquaints or updates on OT&E subjects e.g., analysis, test plan development and threat updates. To assist their personnel in managing OT&E, OPTEVFOR publishes the OT&E Director's Guide which documents its philosophy and methodology.[Ref. 21]

b. DOT&E

Military personnel assigned to DOT&E are selected by background and expertise, and are preferably war college graduates with joint experience. They are interviewed by their potential immediate superior, and by DOT&E himself, before their appointment is confirmed. DOT&E is platform, rather than functionally

organised, so specialist surface warfare, aviators and submariners are preferred. Although DOT&E does not conduct courses for new personnel, a one month handover is usually required. It does, however, publish a comprehensive staff orientation guide and some personnel have attended the OPTEVFOR OTD course. [Ref. 19]

H. USN OT&E IMPLEMENTATION - THE DDG-51 PROGRAM

The objective of the DDG-51 Program is to build the next class of destroyer to replace the aging 'Coontz' (DDG-37) and 'Charles F. Adams' (DDG-2) classes. The first of the class, the USS ARLEIGH BURKE has recently completed OT-III. It is the latest USN surface warship to undergo OT&E, thus serving as the most recent example of the implementation of USN OT&E policy and procedures. The DDG-51 Program is under the management of the AEGIS Shipbuilding Program Manager (PMS 400) and is sponsored by the AEGIS Program Sponsor (N865G). PMS 400 is chartered to provide comprehensive direction and program management for all aspects of system development, ship acquisition and lifetime support preparation. In this task, PMS 400 has the traditional USN responsibilities of a ship acquisition program manager and also bears broadened responsibilities for the fleet introduction and lifetime support of the DDG-51 class ships.[Ref. 33:p. 1]

1. Critical Issues

The Critical Operational Issues for the DDG-51, as defined in the TEMP, are subdivided into effectiveness and suitability issues. [Ref. 31:p. IV-2] The effectiveness issues for DDG-51 are:

- Combat System Performance
- Mobility System Performance
- Command, Control and Communications Performance

- Support System Performance
- Survivability
- Tactics

The suitability issues considered critical for DDG-51are:

- Reliability
- Maintainability
- Availability
- Logistic Supportability
- Compatibility
- Interoperability
- Training
- Human Factors
- Safety
- Documentation
- Software Supportability

2. DDG-51 OT&E Program

These COIs were assessed in a multi-phased OT&E program as shown in the schedule in Figure 8.

a. Initial OT&E

OT-II was split into two major system areas, Propulsion System and Combat System and was conducted at Land Based Test Sites.

(1) OT-IIA Propulsion System Testing was conducted on the DDG-51 Propulsion System at the Gas Turbine Ship Land-Based Engineering Site (GTSLBES), Naval Ship Systems Engineering Station (NAVSSES), Philadelphia, Pennsylvania. It is an Engineering Development Model that includes the Machinery Control System, Data Multiplex System and the engines, reduction gears, thrust

bearings and propulsion-related auxiliaries of the complete DDG-51 system. A water brake was used to simulate the propeller. The GTSLBS was exercised in a simulation of the operational environment of DDG-51class ships. Casualty control drills, maintenance demonstrations, and individual ship propulsion events were conducted during 424 hours of test operations.These included full power runs and emergency crash astern maneuvers. The system was assessed to be potentially operationally effective and potentially operationally suitable.[Ref. 31:p. IV-5]

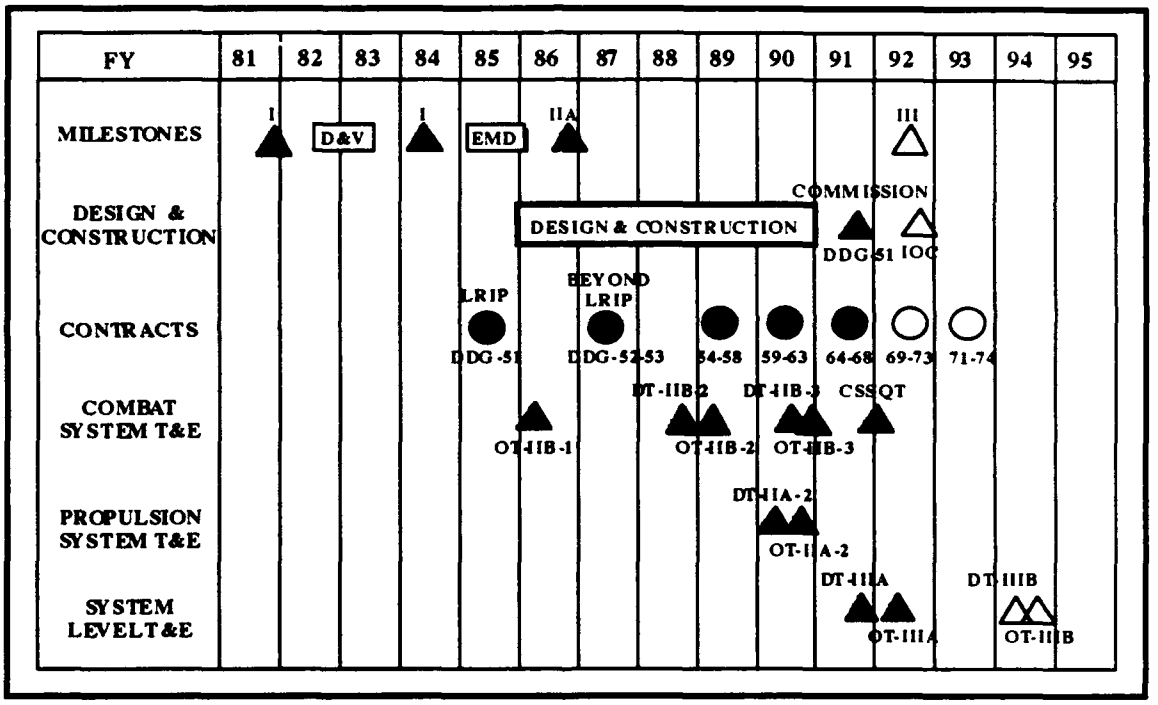

Figure 8: DDG-51 Integrated Test Program Schedule [Ref. 31]

(1) OT-IIB Combat System Testing was conducted at the Combat System Engineering Development Site (CSEDS) Moorestown, New Jersey. Following a philosophy of build a little, test a little, OT-IIB was conducted in three

phases. OT-IIB-1 was conducted in Jun 1986 on a partial configuration in an early stage of development and integration to support the program Milestone IIIA decision. The capability in all mission areas could not be evaluated with only search, detection and tracking of AAW targets conducted. No engagements of air targets were conducted. Twelve raids of multiple aircraft were conducted, of which eleven were in an ECM environment, including various jamming modes and chaff. Dynamic Test Targets (DTT) were also introduced to evaluate system performance. COMOPTEVFOR concluded that the combat system demonstrated the capability to control, integrate, and display information required for tactical decisions on AAW targets and recommended approval of the DDG-51 Combat System for limited fleet introduction. [Ref. 31:p. IV-4]

(2) The second phase (OT-IIB-2) was conducted in September 1988 when the CSEDS represented an operational prototype replicating planned human factors, sensors, information processing and weapons system installations in the real DDG-51. Assessment of capability in all mission areas was conducted. Thirty-four raids of manned aircraft were conducted, of which two only were in a clear environment. Additionally DTTs were also introduced to represent antiship missiles and surface hostile threats. Threat submarine evaluations, both active and passive were conducted as were Link 11 operations with aircraft, surface ships and shore stations. Non firing engagements with both Harpoon and Tomahawk were also conducted. Operational Suitability data were collected during the period. On test completion, COMOPTEVFOR recommended continued development of the Combat System and the conduct of an additional phase of OT-II at CSEDS prior to sea trials.

(3) The third phase (OT-IIB-3) was conducted in August 1990 following further development of the Combat System. The testing was

comprehensive of the total Combat System's capabilities. COMOPTEVFOR noted that performance was notably improved since the conduct of OT-IIB. They assessed the system as being potentially operationally effective and potentially operationally suitable, and recommended continued development of the Combat System. [Ref. 31:p. IV-6]

OT-IIB-2 and OT-IIB-3 were conducted to support continued limited production. DDG-51 crew members participated in the OT-II testing, both at the GTLBES at NAVSSES and in CSEDS testing.

b. Follow On OT&E

(1) OT-IIIA was conducted for a 28 day period in early 1992 on board USS ARLEIGH BURKE. Air, surface and subsurface targets were presented in single and multithreat environments. Simulated firings against manned aircraft and live firings against threat-representative targets in operationally realistic scenarios were conducted in order to evaluate the performance of the integrated combat system and the capability of the mobility and support systems to support the ship's mission. The performance of all the ship systems designed for operation with other Navy units was also evaluated. Suitability tests, off-ship support and maintainability demonstrations were also conducted. [Ref. 31:p. IV-9]

(2) OT-IIIB is planned to be conducted in a DDG-51 class ship to demonstrate correction of deficiencies identified during OT-IIIA and to include previously untested systems.

(3) OT-IV will be conducted in a DDG-51 class ship to demonstrate correction of deficiencies, to complete deferred or incomplete OT&E, and to evaluate major computer software revisions as well as the DDG-51 class performance in battle group operations.

c. *Timing of OT-III*

Table 6 shows the Post Delivery Schedule of DDG-51. Of interest is the timing of OT-III within the ship's program. Note that OT-III is scheduled immediately after DT-III testing and before the Workup (REFTRA and FLEETEX). This has the disadvantage of OT&E not being conducted on a fully worked up ship with the crew still Developmental Testing oriented. This may have prejudiced the OT&E results.

TABLE 6: USS ARLEIGH BURKE - POST DELIVERY SCHEDULE [Ref. 33:p. 5]

Time	Activity
D + 1 month	Mobile Training Team / Training Readiness Evaluation
D + 2 m	Light Off Examination / Fast Cruise / Commissioning / Port Visit
D + 3-4 m	Combat Systems Ship's Qualification Trials (CSSQT)
D + 5 m	DT-III (Demonstrate ship performs as designed)
D + 6 m	Final Contract Trials / **OT-III**
D + 7 m	**OT-III** / Operational Propulsion Plant Examination
D+ 8-10 m	Post Shakedown Availability (PSA)
D+ 11 m	Refresher Training (REFTRA)
D+ 12 m	Fleet Exercise (FLEETEX)
D + 13 m	Upkeep (Maintenance Period)
D + 14 m	OT-IV (Backup Events)
D + 15 m	FLEETEX / Battle Ready
D + 16 m	Pre Overseas Movement / Deploy

3. 'Whole Ship' OT&E

OT-III conducted on the DDG-51 was unique in that it was the first time the USN has conducted OT&E on a whole ship in a multi-battle situation, in a fairly free play environment. Previous ship OT&E, e.g., on the "Aegis" class cruisers (CG-47), was essentially a combat system test based on a proven hull, where the rest of the ship and ship integration were not tested. DOT&E have been instrumental in intensifying efforts to create an operational environment.

a. OT&E Program Development

Following the guidance contained in the OTD manual [Ref. 15], OPTEVFOR developed a test design matrix. This matrix mapped the Top Level Requirements to the Schedule of Events (SOE). The TLRs were general and related to the warfare areas of AAW, ASW, ASUW and STW. The purpose of the matrix was to ensure that all TLRs were covered by an operational test. In the event that test resources became unavailable or a system casualty occurred, the matrix provided a reference of what had been accomplished, what remained to be accomplished, and the feasibility of completing the test objectives if OT was to continue. In the evaluation period, the "as-run SOE" was laid out chronologically, identifying events by mission areas. By examining the as-run table, individual mission areas were identified for analysis and periods of multiwarfare could be identified to look at synergistic effects.[Ref. 21]

b. Integration of Engineering and Combat System Events

Whole ship testing includes engineering and technical problems combined with combat system activity. The OPTEVFOR Operational Test Director controls the program and controls injection of incidents. A balance must be achieved

between engineering incidents and related degradation of the combat system to ensure the overall aim of the test is achieved.

c. Operational Realism

The OT&E emphasised operational realism by testing the ship as though in war, with a full political background to set tone and flavor. The situation consisted of an overall 28 day mission consisting of individual, but interlinked, scenarios. The scenarios were developed to examine the ship's capability to operate as a fleet asset and to stress the installed combat systems' capabilities against the threat. They were designed to provide a realistic threat in an operational environment and an element of surprise to provide realistic tests to support completion of the OT&E objectives and resolutions of the COIs. The Commanding Officer, Combat Information Centre team and the ship's crew were allowed to respond to the tactical situation as they perceived it.[Ref. 31:p. IV-9] To enforce realism, operational message traffic flow at the same rate that could be expected in a conflict was maintained and Damage Control incidents were introduced.

d. Limitations to Scope of Testing

Despite the efforts for realism, certain practical considerations, time restrictions and resource constraints limited the scope of operational testing. These were [Ref. 31:p. IV-10]:

- Targets and ECM did not fully replicate the threat in numbers and characteristics thus precluding fully threat representative raids.
- The CIWS, ESM and ECM were not tested using drone targets. Manned aircraft were used for ESM and ECM tests and a towed target was used for CIWS firings.
- The number of missiles available precluded reengagements and multiple salvo engagements in some scenarios.
- The geographical location of test ranges and their facility and equipment

limitations precluded fully threat representative target presentations, target density and open ocean geometries.

- The duration of the operational testing precluded determination of reliability and other suitable parameters, forcing the use of development testing data where credible and applicable.
- Operations were not conducted in all weather, temperature, humidity, and wind and sea conditions.

e. DDG-51 OT&E Analysis

The OT&E of DDG-51 highlighted a number of overall considerations.[Ref. 21]

(1) Interfaces. Interfaces are important to consider in whole ship testing, particularly individual systems with their own TEMPS and test plans. Whole ship OT&E looks at whole mission system and ship performance e.g., not just sonar performance but ASW system performance. Problems occur with concurrent sub-system and whole ship testing due to different critical issues and objectives of testing which create conflicts during testing. One overall test plan resolving these issues is required.

(2) Statistical Significance. Some tests, e.g., Tomahawk firing, can only be done once. To achieve results of statistical significance, a number of simulation runs were conducted using new and varied scenarios. The one firing was then used to verify the simulation. This demonstrates the use of simulation to extend the test results.

(3) Qualitative vs. Quantitative. Effort was made throughout DDG-51 OT&E to use quantitative thresholds based on quantitative numbers, whereas, previous OT&E of the AEGIS class cruisers (CG-47) qualitatively assessed all COIs.

(4) Operationally Realistic Scenarios. To improve the measurement of AAW mission performance against a threat representative target in a threat operational scenario, particularly in the light of the "Iranian Airbus" issue, AAW scenarios now do not necessarily include everything that flies is hostile. To add to the operational flavor, a political situation and Rules of Engagement (ROE) are used during OT&E. These ROEs change due to the political situation or opposing force actions e.g., switching on fire control radar. This level of testing adds to the analysis problem e.g., having to cross the Electronic Warfare detection of a Fire Control radar to the aircraft, with the subsequent need for overall exercise analysis.

(5) Crew Stress under Battle Conditions. The DDG-51 OT&E program include the measurement of crew stress under battle conditions, both during the land based and at sea testing. They observed that the land based level of operator performance was significantly better than at sea. The USN is continuing to pursue methods to take measurements to determine how much of the performance degradation from land based testing to at sea testing is a result of the personnel. The man machine interface, the concept of human factors and operational stress are a great contributor to overall system performance. One objective of the OT&E program was to keep the crew busy during the test period.

(6) System Problems vs. People Problems. One aim of OT&E is to assess the human factors relating to system performance which involves assessing the adequacy of training, ease of use, etc. It does not include the performance assessment of an individual. This can sometimes be difficult when people form a vital part of the system. OPTEVFOR stress they are not drilling the crew, but demonstrate how the system (which may include people in the loop) responds. It is, therefore, important for the crew to be 'worked up" to normal fleet standards prior to OT&E.

(7) Independent Third Party Data. OT&E needs to be conducted on a range or with another ship/aircraft to get independent third party data to be able to reconstruct the evolution. The philosophy of testing is that the item under test is immediately suspect so if data from this system is required, then it needs to be verified. It may be sample verified so that 100% duplication is not required.

(8) Program Manager Perception. Although many program managers may see OT&E as an annoyance and unnecessary burden to their program, PMS 400 sees OT&E as an independent assessment to demonstrate that its on the right track and doing the right thing. [Ref. 22]

I. U.S. DEPARTMENT OF DEFENCE OT&E ISSUES

U.S. DoD authorities involved in ship OT&E see a number of macroscopic issues relating to OT&E in the USN today.

1. Impact of Budget Cutbacks

a. Acquisition Strategy

As a result of budget cutbacks, the Secretary of Defence is developing a new acquisition policy for systems that don't go into a long protracted production phase. A prototyping acquisition strategy may be implemented where one of kind is built and the technology is either put on the shelf, or into limited production to keep defence industry active. More emphasis may be placed on R&D than on production. Questions arise as to how OT&E fits into an acquisition strategy that does not lead to production, and should more reliance now be placed on DT&E and less on OT&E.[Ref. 19] Current thinking is that more importance may be placed on modeling and simulation to estimate operational effectiveness and operational

suitability of advanced technical demonstrators, to minimise the operational risk if production and deployment is required in an emergency.

b. OT&E Conduct

Questions arise also of how OT&E is to be conducted in a reduced budget environment. With reduced production runs, the relative cost of OT&E in relation to overall program cost will increase. This may not be seen as acceptable and pressure may be applied to reduce the absolute cost of OT&E. The breadth of assessment may be diminished using less test assets. There may be also a possibility of a central OT&E agency. With DOT&E becoming an increasingly aggressive participant in OT&E, testing in the future could be directed exclusively by DOT&E.[Ref. 19]

c. Increasing Modeling and Simulation

Modeling and simulation (M&S) capabilities are going to play a larger role in contributing to the OT process. Although M&S will never replace operational testing, it will be able to supplement actual testing to a greater degree in certain areas. Technological advances in M&S may make these tools now more of a candidate to be used for OT&E. Typically M&S is more of a study or analysis or developmental type tool, but are rapidly developing capabilities that will offer advantages to the OT process.[Ref. 19][Ref. 21]

2. Operational Realism

Following GAO criticism of lack of realism [Ref. 36] and the 'whole ship' OT&E concept, test scenarios can be expected to be more realistic in the future. To obtain the maximum benefit from operational tests, they will also need to be more quantitative. This may include the development of integrated multiwarfare ranges to support whole ship testing.[Ref. 19][Ref. 21]

J. USN OT&E SUMMARY

1. Importance of OT&E

OT&E is the "final exam" in the U.S. DoD acquisition process, an empirical method of ensuring that sufficient technical return is made on acquisition investments and that a new system is fully capable of meeting the Fleet's needs prior to production [Ref. 12]. As a result, the U.S. place high importance on OT&E. The requirement for the conduct of OT&E is mandated by Congress and incorporated in the laws of the U.S. OT&E is viewed as being more important as a basis for a decision to proceed beyond LRIP, than on the introduction into service of the final production item. This is because the "big bucks" of most Defence acquisitions are spent during the production phase. OT&E, however, continues to play an important role in the assessment of systems for Fleet Introduction and has increased its importance in the assessment of complete ships for Fleet Introduction.

2. Need for OT&E

The USN need for OT&E stems from the almost exclusive reliance by the U.S. on indigenous weapons development and production. They have a history of large, risky, developmental programs which push the state of the art in weapons technology. The outputs of these programs require the assessment of operational effectiveness and suitability before being committed to production and subsequent introduction into the fleet. The U.S. has been involved in a number of military conflicts which demonstrate the need for operationally effective and suitable systems. The lessons learned from Vietnam, and Gulf operations including the USS STARK and USS VINCENNES incidents, highlighted problems which DT&E alone may not identify.

3. OT&E Agency Independence

Independence is the key to the effectiveness of OT&E in the U.S. acquisition process. OPTEVFOR is the sole independent OT&E agency within the USN, reporting directly to CNO, and DOT&E provides independent oversight and coordination of the military services' planning and execution of OT&E, reporting directly to the Secretary of Defence. OT&E agency independence is designed to ensure impartiality, honest and open reporting, with a minimum of political interference.

4. T&E Delineation

The USN have a clear delineation between the different types of T&E. OPTEVFOR conduct only OT&E, and OT&E within the USN is conducted solely by OPTEVFOR. Thus, there appears to be good understanding in the USN of what is, and what isn't, OT&E.

5. Whole Ship OT&E

Whole ship OT&E is conducted in a dedicated period following CSSQT and Final Contract Trials, and consists of fully assessed free play, multi-threat scenarios. The whole ship is viewed as an integrated warfare system, rather than as a platform for warfare systems.

6. Clear Guidance

The requirement for OT&E, and its organisation and methodology are well documented within the USN, providing clear guidance to acquisition and operations personnel. Also, training in OT&E is provided, further improving the capability and understanding of personnel involved with OT&E.

7. Summary

The USN OT&E system has, by necessity, developed into a comparatively well organised, well documented and effective, if complex, system that meets the requirements of the U.S. Defence acquisition process.

IV. RAN SHIP OPERATIONAL TEST & EVALUATION

The recent disestablishment of the RAN's independent Operational Test and Evaluation authority, the RAN Trials and Assessing Unit (RANTAU), and its subsequent integration with Maritime Headquarters (MHQ), marks a continuing shift in RAN OT&E policy. This chapter describes the RAN OT&E system, its relationship with the other categories of T&E and its role in the RAN ship acceptance process. As RAN T&E documentation does not yet reflect the disbanding of RANTAU, the OT&E system is described as it was prior to May 1992, and then the new organisation will be introduced.

A. AUSTRALIAN DEFENCE ACQUISITION PROCESS

Acquisition of major capital equipment for the Australian Defence Force (ADF) is managed by the Capital Procurement Organisation (CPO) within the Department of Defence. The defence system life cycle consists of the following phases:

- Conceptual
- Demonstration and Evaluation
- Full Scale Engineering Development
- Production
- In Service

Similar, but not identical, to the U.S, system, these phases are generally separated by the following milestones:

- Program Initiation
- Full Scale Engineering Development
- Production Approval

- Preliminary Acceptance (PA)/ Delivery
- Acceptance into Naval Service (AINS)
- Operational Acceptance (OA)

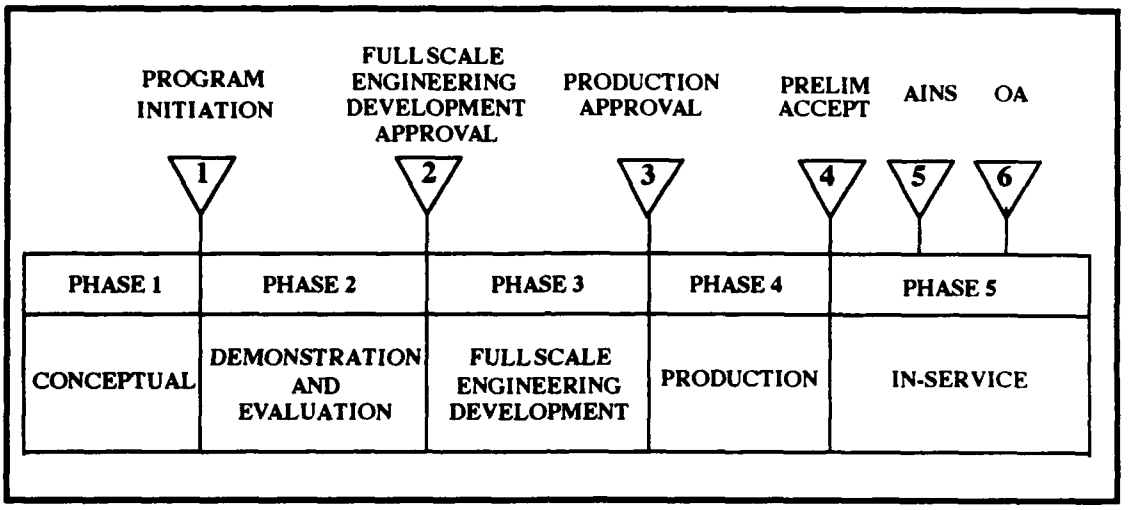

Figure 9: Australian Acquisition Process for Major Programs

1. Development Vs. Procurement

The completion of all acquisition phases applies only to indigenously developed systems. Systems procured overseas generally undergo only those phases from Milestone 3 onwards. Due to the RAN's small size and limited requirements, it is not practical or achievable to develop all required systems locally. In many cases, systems with the fundamental capabilities required by the ADF are available overseas, however, some of these systems require additional development, adaptation or integration to meet Australian specific requirements. Many of these systems require only minimal adaptation (e.g., in their communications fit), while others are more extensive (e.g., ANZAC class frigates and COLLINS class submarines). This leads to different types of system acquisition programs.

2. Types of Acquisitions

The following are the principal ways Australia acquires defence capabilities [Ref. 6:p. 86]:

a. Indigenous Design and Development

Local research and development can be undertaken to meet special local requirements, or as consequence of research undertaken to maintain the technology base. The new system is subject to all phases of the acquisition process.

b. Local Development and Production

Naval Adaptation programs in which an overseas design is purchased, but then undergoes modifications to meet specific RAN requirements. Some engineering development work may be needed.

c. Local Production of Overseas Designs

In some cases, the requirements of the ADF can be met most cheaply and expeditiously by existing overseas systems where there is no economic or technical prospect of a local competitor. The system may be built locally, where it would be subject to Production Approval.

d. Import of Overseas Equipment

Non development programs, where systems are purchased "off-the-shelf" from a foreign source, without modification, are subject to the acceptance milestones only.

Each of these types of acquisition differ in their technical and operational risk and hence T&E requirements. In general, Australia has a policy of buying low risk, operationally proven systems, which may be modified to meet local requirements.

B. AUSTRALIAN DEFENCE T&E DEFINITIONS

The categories of ship T&E used in the Australian DoD have been derived from the U.S. DoD instructions, but interpreted to accord with Australian requirements [Ref. 38:p. 14-1]. There is a hierarchy of documents pertaining to T&E within the DoD and RAN.

1. DoD T&E Definitions

At the DoD level, the Australian Capital Equipment Procurement Manual (CEPMAN 1) [Ref. 38] defines the types of T&E applicable to the Australian DoD as follows:

a. Development Test and Evaluation (DT&E)

DT&E assists the development specification, design and procurement process and to verify the attainment of development specifications.

b. Production Acceptance Test and Evaluation (PAT&E)

PAT&E is to assist the development of a procurement specification and to verify compliance with its requirements. It is generally associated with a production activity and normally forms the basis of qualified acceptance of the equipment.

c. Operational Test and Evaluation (OT&E)

OT&E is to assist the development of an operational capability specification and to measure compliance with its requirements. CEPMAN 1 also defines a sub-grouping within the OT&E classification - the Operational Evaluation (OPEVAL). An OPEVAL covers tests and evaluation on production representative

baseline equipment using the maintenance and support personnel and equipment for normal operational use and aims to:

- Demonstrate operational effectiveness and suitability
- Provide data to assist in the development of tactical aspects of the equipment.
- Verify data, handbooks and documentation covering the operation of the system.

2. RAN T&E Definitions

These DoD definitions are further refined by the RAN. The Defence Instruction for RAN Test and Evaluation Policy [Ref. 44] defines the types of T&E as follows:

a. Development Test and Evaluation (DT&E)

DT&E denotes that T&E conducted in order to demonstrate the progressive achievement of design requirements and to show that the article will meet its technical specifications. DT&E is divided into three phases as shown in Table 7.

TABLE 7: PHASES OF DT&E [Ref. 44:p. 2]

T&E Type	Description
DT-1	Validation of design concept
DT-2	Proving design
DT-3	Demonstration that production meets required technical characteristics

b. Production Acceptance Test and Evaluation (PAT&E)

PAT&E denotes that T&E conducted by or on behalf of the procurement agency to determine whether contracted provisions have been satisfied. PAT&E is divided into two sections with a total of eight phases as shown in Table 8.

TABLE 8: PHASES OF PAT&E [Ref. 44:p. 2]

PAT&E Part	T&E Type	Description
Part 1	PAT-0	Design and engineering development tests
	PAT-1	Production and burn-in tests
	PAT-2	Environmental qualification tests
	PAT-3	System development tests
	PAT-4	Harbour testing
	PAT-5	Sea testing
Part 2	PAT-6	Operational and Qualification Trials (conducted with OT-3)
	PAT-7	Follow on Operational T&E (conducted with OT-4)

c. Operational Test and Evaluation (OT&E)

OT&E is that T&E conducted to estimate the operational effectiveness and suitability by an authority independent of the development and production agencies. OT&E is divided into five phases as shown in Table 9. Of note is that Certification/Qualification trials are included in OT-3. These trials consist of Communications, Emitter and other individual system certifications. These trials

also include a five to seven week Combat System Ship Qualification Trial (CSSQT) that:

- Demonstrates the maintainability and operability of those equipments/ systems that are included in the CSSQT program through accomplishment of equipment/system Planned Maintenance System (PMS), aircraft/balloon tracking exercises, practice missile firings and culminating in live firing exercises.
- Provides training and familiarisation to ship personnel in the maintenance and operation of the installed equipments/systems that are included in the CSSQT program.
- Identifies design problems in the equipment/system installed.
- Identify any deficiencies that may exist in the CSSQT support elements, i.e., documentation, logistics, test equipment or training.

TABLE 9: PHASES OF OT&E [Ref. 44:p. 2]

T&E Type	Description
OT-1	*Operational assessment of the development proposal*
OT-2	Demonstration of achievement of program requirements for operational effectiveness and suitability of a prototype (OPEVAL) to support proceeding to full production
OT-3	Demonstration of achievement of program requirements for operational effectiveness and suitability on production of ship/ aircraft/system, normally in independent operations using normal Fleet personnel. **Certification/Qualification Trials** include limited reliability, maintainability, availability and logistic supportability assessments.
OT-4	Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/aircraft/system using normal Fleet personnel in a multi-force, multi-threat environment, Includes detailed reliability, maintainability, availability and logistic supportability assessments.
OT-5	Follow-on OT for assessment after modernisations, new applications or defect rectifications after OT-4

C. T&E IN THE ACQUISITION PROCESS

1. The Need for T&E

The most recent Australian Government "White Paper" on defence policy [Ref. 6:p. 70] states:

> We need to be able to determine the performance in our own environment of equipment of both overseas and local origin and to modify and adapt overseas equipment as necessary to improve its performance in our likely theatres of military operations.

Also, the guidance for Australian defence acquisition [Ref. 38:p. 14-1] recognises that:

> The evaluation of military weapons systems and their individual component systems is essential to this policy. Analysis of the results of testing performed as part of the Test and Evaluation (T&E) of a capital equipment project may assist in the identification of problem areas, allow timely corrective action to be taken, and reduce the element of risk in major decisions.

So the need for local T&E is recognised by the Australian Government and the DoD, for both indigenous and overseas systems. The responsibility for T&E of a system rests with organisations with responsibility for the design approval, certification or procurement of equipment, who have the authority and responsibility to conduct (or require the conduct of) T&E. All project requirements are coordinated by the Project Manager, who considers whether or not T&E can be conducted within available project resources.[Ref. 38:p. 14-2] However, the importance of OT&E in particular, is not specifically addressed in any of these T&E policy documents.

2. OT&E Contributions at Major Milestones

OT&E in the RAN may be conducted during each phase in the acquisition process, but it is not essential to a local system meeting a development or production

milestone, or the local production or purchase decision of an overseas system. It is however, required before a system achieves Acceptance into Naval Service or Operational Acceptance. The phasing of T&E during the acquisition process is detailed in Figure 10.

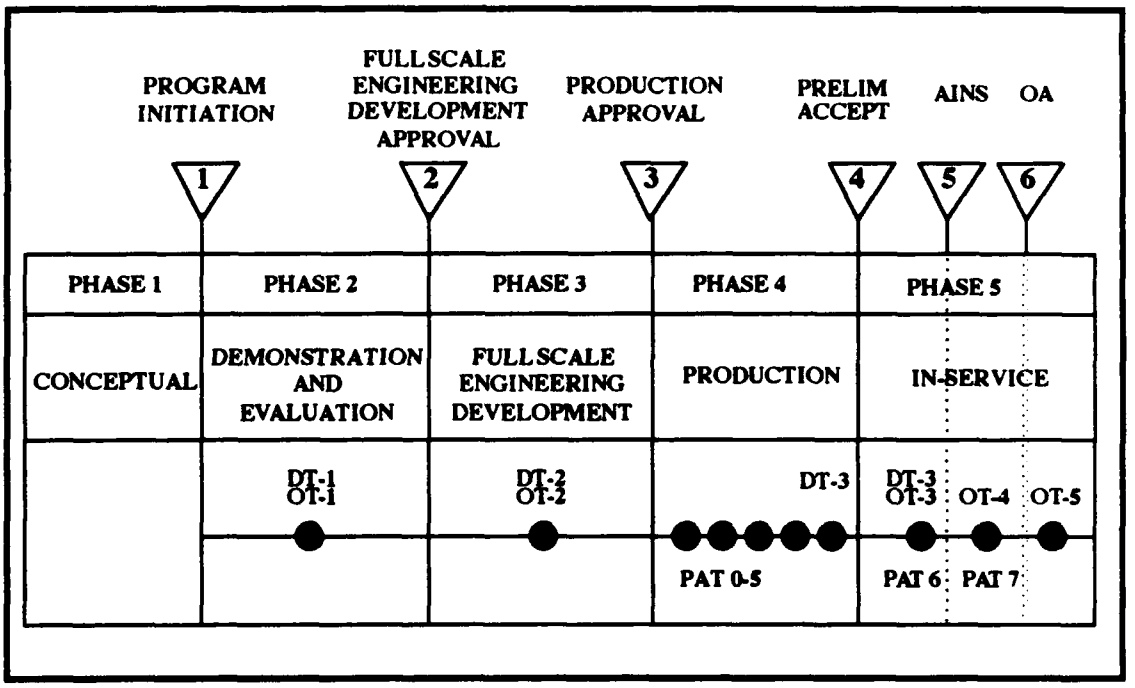

Figure 10: Test & Evaluation in the Acquisition Process [Ref. 44:p. B-1]

The contribution of OT&E to the acquisition milestones includes:

a. OT&E prior to Program Initiation

No role is documented for OT&E in the Conceptual Phase.

b. OT&E prior to Engineering Development Approval

During the Demonstration and Evaluation Phase, an operational assessment of the development proposal (OT-1) may be conducted. The results of

which may contribute to the decision to undertake Full Scale Engineering Development.

c. OT&E prior to Production Approval

Towards the end of the Full Scale Engineering Development Phase, a demonstration of achievement of program requirements for operational effectiveness (OT-2) and suitability of a prototype (OPEVAL) to support proceeding to full production. This phase may include system/software assessment at a Land Based Test Site [Ref. 44:p. 2]. The results of OT-2, if conducted, may be used to support a local production or purchase decision.

d. OT&E prior to Preliminary Acceptance

No role is documented for OT&E in the Production Phase.

e. OT&E prior to Acceptance into Naval Service

Although Figure 10, indicates an OT-3 phase prior to AINS, no specific requirement is documented in RAN policy for the conduct of OT-3 prior to AINS. The prerequisites for AINS detailed in Reference 41 p 15.11, are described in terms of PAT&E Part 2, and make no mention of OT&E. At the working level, however, the RANTAU Standard Operating Procedure for OT&E [Ref. 53] includes the conduct of OT-3 prior to AINS, and the results of OT-3 have usually been considered in the AINS decision.

f. OT&E prior to Operational Acceptance

For first of class ships it will not normally be possible to trial and evaluate all aspects of the operational performance and maintainability prior to AINS. Therefore, the first of class usually undergo follow-on OT&E (FOT&E) after

AINS, leading to Operational Acceptance [Ref. 44:p. A-1]. This OT-4 Phase consists of:

- Evaluating the ship as part of a force during an exercise, in order to develop standard operating procedures and tactics, and to explore the limits of capability, etc.
- Evaluating the maintainability and stores support for equipments and systems to determine whether or not the complement t, stores allowances, documentation are adequate. [Ref. 41:p. 15.14]

g. OT&E Contributions post Operational Acceptance

OT-5 is follow-on OT&E for assessment after modernisations, new applications or defect rectifications after OT-4 [Ref. 44:p. 3].

The OT&E contributions to the Acquisition Milestones are by no means definitive. There is no documented requirement for the conduct of OT-1 and/or OT-2 prior to a production or purchase decision of major acquisitions. The decision to conduct OT&E being the responsibility of the Sponsor, Project Manager and the Defence Acquisition Committees. RAN T&E policy documentation almost exclusively focuses on the post production acceptance phases. Even during the acceptance phase, however, the requirement for OT-3 is clouded in definition differences between policy documents. The RAN appears to have its focus on Production Acceptance Testing, possibly because most systems procured in the past, were already in service with a large parent Navy. Tactical development was not necessary because the tactics also were acquired with the system.

3. Production Acceptance Test and Evaluation

As defined previously, Production Acceptance Test and Evaluation (PAT&E) is the testing conducted to demonstrate that systems meet contract specifications and requirements: also that items/systems are properly installed and operable onboard the ship. The objective of PAT&E is to confirm that the contractor

has met contractual obligations, and hence the Commonwealth may correctly take delivery of the ship.[Ref. 41:p. 14-2] Much emphasis is given within the RAN to PAT&E, known under various terms including Inspections, Tests and Trials (ITT), Harbour Acceptance Trials (HATs) and Sea Acceptance Trials(SATs). In recent years the RAN has adopted the U.S. Total Ship Test Program (TSTP) concept, initially with the modernisation of the DDGs, and now in the testing of the locally produced FFG-7 class, under the Australian Frigate Project. The adoption of the TSTP by the RAN included the redefinition of the test phases. Where the U.S. system included only PAT&E, the RAN has included elements of DT&E and OT&E, in addition to PAT&E, and gave them PAT designations.

a. Integrated Test Package

Under the TSTP, the program and content of the formal ITT required by the contract is usually designated the Integrated Test Package (ITP). Although in the Australian system, Government testing is also included. The categories of ITT testing are listed in Table 10.

TABLE 10: CATEGORIES OF ITT [Ref. 41:p. 14.3]

PAT&E	Category	T&E Type	Description
Part 1	0	PAT-0	Design and engineering development tests
	1	PAT-1	Production and burn-in tests
	2	PAT-2	Environmental qualification tests
	3	PAT-3	System development tests
	4	PAT-4	Harbour testing
	5	PAT-5	Sea testing
Part 2	6	PAT-6	Ship Operational and Qualification Trials
	7	PAT-7	Follow on Operational T&E

b. Overlap of PAT&E and OT&E

PAT&E Part 2 covers the period from Preliminary Acceptance to the AINS and equates to PAT-6. The Project Director has responsibility for the program and its funding and RANTAU is responsible for the detailed schedule of events and the provision of test and trials resources. Testing includes:

- Ship's staff familiarization, shakedown and safety drills
- Installation and testing of specialised equipment
- Tempest test
- Harbour trials of weapons, communication and combat data systems, etc.
- Ship Qualification Trials
- Degaussing and Noise Ranging

However, some of these testing activities are also included as part of OT-3, and both PAT-6 and OT-3 are conducted by the same authority (RANTAU), during the same period, and using the same T&E personnel. Similarly, the PAT-7 phase equates to OT-4.

D. RAN OT&E ORGANISATION

The RAN community responsible for planning, programming, budgeting and evaluating OT&E forms an integral part of the more general T&E organisation. OT&E in the RAN is not treated as being special or unique, and no organisation deals solely with OT&E. The RAN organisational structure has changed over the past few years which has impacted on the structure of the OT&E community.

1. OT&E Organisation Elements

The functional elements of an OT&E organisational structure include:

- Policy Maker and Overseer
- Sponsor

- Developing Agency
- Tester and Evaluator
- User
- Coordinator

a. Policy Maker and Overseer.

There is no clear OT&E policy maker within the Australian DoD or the RAN. The Chief of Capital Procurement within DoD has a role in the formulation of capital equipment procurement policy for the guidance of Service Materiel Divisions. The CPO manual [Ref. 38] addresses T&E, but more in the form of guidance rather than policy. The Director General of Naval Warfare (DGNW) in the Deputy Chief of Naval Staff (DCNS) Division, drafted the RAN Test and Evaluation Policy Defence Instruction [Ref. 44]. DGNW however, is now defunct with the result that Test and Evaluation policy for Navy is presently in a state of flux, with no office having assumed the responsibility [Ref. 50].

b. Sponsor

The sponsor is responsible for monitoring operational requirements and warfare concepts, the development of concepts for operations for naval warfare systems, and the raising of staff targets and requirements as required. He/She is also responsible for the subsequent trials and continuing overview to ensure that the equipment meets the requirement. Originally the responsibility of DGNW, this function for major acquisitions was assumed by the Director General Force Development (Sea) in Headquarters, Australian Defence Force (HQADF). This centralised force development and user requirements organisation produces the Naval Capability Proposals (NCP). The decision to subject an acquisition to T&E is initially decided by the sponsor and detailed in the capability proposal [Ref. 44:p. 1]

c. Developing Agency

When a project is approved, a project office is formed within the Materiel Division responsible for acquisition of the capital equipment to meet the approved NCP. The nature and extent of the T&E to be conducted will be decided by the Project Director in consultation with the Design Approval Authority and RANTAU and detailed in the TEMP [Ref. 44:p. 1]. The Project Manager, in consultation with operational, technical and maintenance authorities, is to fully investigate the necessity for, and likely scope of, Defence T&E [Ref. 38:p. 14-5].

d. Operational Tester and Evaluator

The RAN Trials and Assessing Unit (RANTAU) was the RAN's OT&E authority with a mission to provide an independent evaluation, audit and training service in response to current and future Maritime Force requirements. Located in North Sydney, near the main Fleet Base, the trials related functions of RANTAU included[Ref. 43:p. 1]:

- Conduct of operational effectiveness and operational suitability trials on ships and facilities under construction, modernisation, conversion or extended refit in support of AINS.
- Conduct test and evaluations, investigations and inspections of selected equipment when tasked.
- Audit and witness selected Harbour Acceptance Trials (HATS), Sea Acceptance Trials (SATS) and Test Procedures which have operational implications for ships and facilities (now known as PAT 4 and 5).
- Conduct Ship Qualification Trials.

RANTAU, although the OT&E authority, also conducted PAT&E on behalf of Project Directors and/or the Maritime Commander. With the disestablishment of RANTAU in May 1992, the trials functions were transferred to

the Commander, Test and Evaluation (CTE) under the Chief Staff Officer (Engineering) in the Maritime Command.

e. User

The Maritime Commander, and the individual ships' Commanding Officers and crews are the ultimate users of a ship, RAN T&E documentation, however, does not address their involvement in T&E. The Commanding Officer of a ship under test usually provides RANTAU with his opinions on the ship's performance at the conclusion of a trials period.

f. Coordinator

The Director of Naval User Requirements (DNUR), under DGNW, once acted as the Navy Office representative for RANTAU within Navy Office, Canberra. He provided a coordination/liaison role between RANTAU and the Materiel Division, by attending project meetings and highlighting T&E requirements.

2. Changes to the RAN OT&E Organisation

The OT&E organisation within the RAN has changed dramatically over the past few years. Figure 11 illustrates the OT&E organisation in 1987. The Director, RANTAU (of Captain rank) was directly responsible to the Assistant Chief of Naval Staff - Development (ACDEV-N). Also under ACDEV-N, the Director General Naval Warfare (DGNW) sponsored all major acquisitions, and gave T&E policy direction. Under DGNW, the Director of Naval User Requirements (DNUR), provided RANTAU representation and performed an OT&E coordination role within Navy Office. Thus the OT&E authority was responsible to the developer of the user requirement, and was independent of the developing and production agencies.

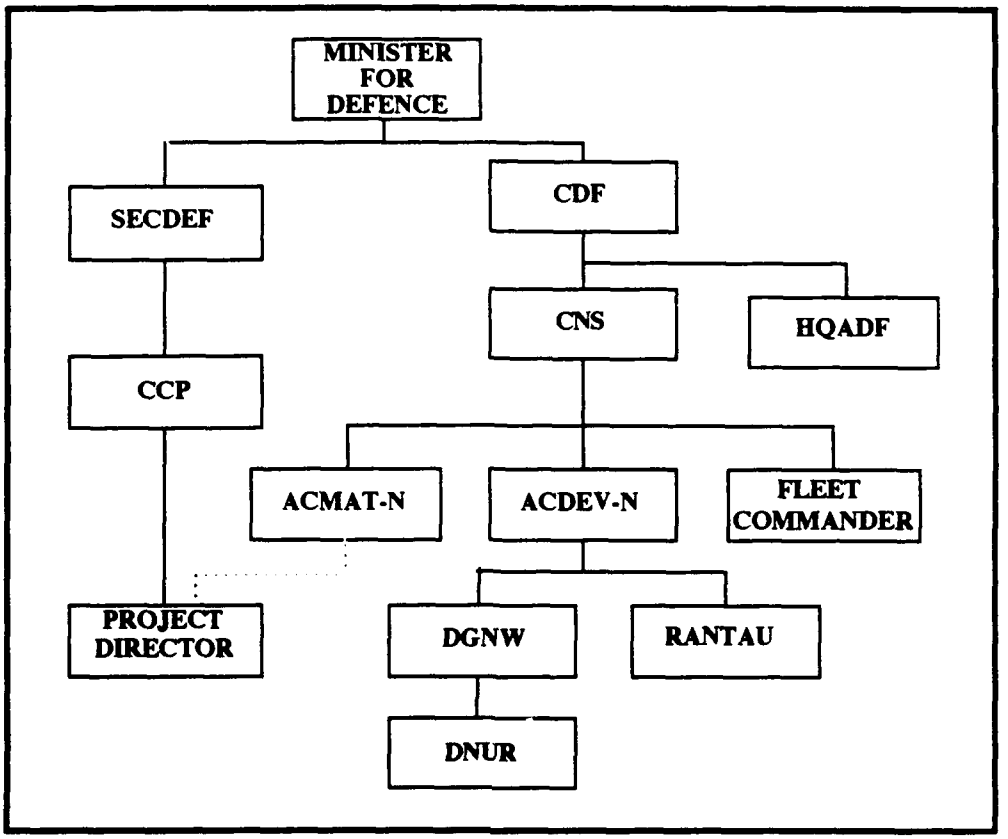

Figure 11: RAN OT&E Organisation circa. 1987

By 1990, the structure outlined in Figure 12 had developed. With the centralisation of military policy development and resource planning, the Development Division within the RAN was disbanded. DGNW, with reduced user requirement responsibilities, moved under the Deputy Chief of Naval Staff (DCNS), The emerging HQADF now became the Sponsors for major acquisitions. The Director General Force Development (Sea) (DGFD(SEA)) having particular responsibility for "Sea" Capability Proposals [Ref. 54]. DGNW, however, retained responsibility for T&E policy within the RAN. RANTAU was also transferred under

DCNS. As the sponsorship of major acquisitions was now held by HQADF, the OT&E authority was now no longer responsible to the developer of the user requirement. DNUR was dissolved and the OT&E authority lost its representation in Navy Office.

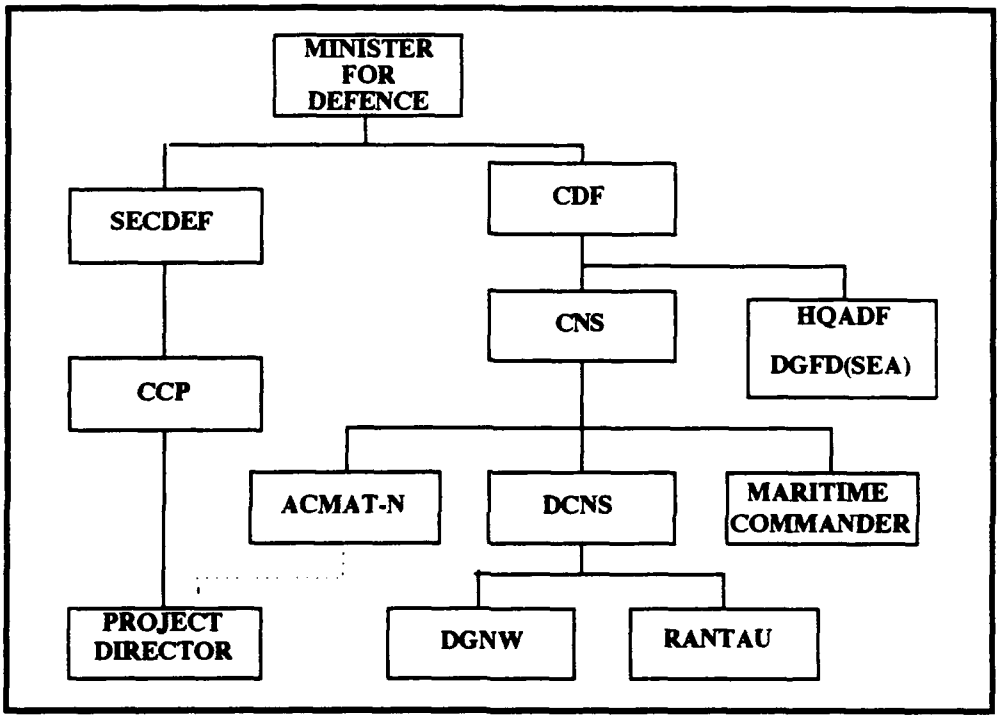

Figure 12: RAN OT&E Organisation circa. 1990

By the end of May 1992 (Figure 13), RANTAU was disestablished and its trials functions were transferred to the Maritime Commander as the Commander Test and Evaluation (CTE) under the Chief Staff Officer (Engineering) (CSO(E)). DGNW was dissolved and his now reduced functions were assumed by the Director

Naval Warfare (DNW) under the newly created Director General Naval Policy and Warfare (DGNPW) [Ref. 55] within the DCNS Division.

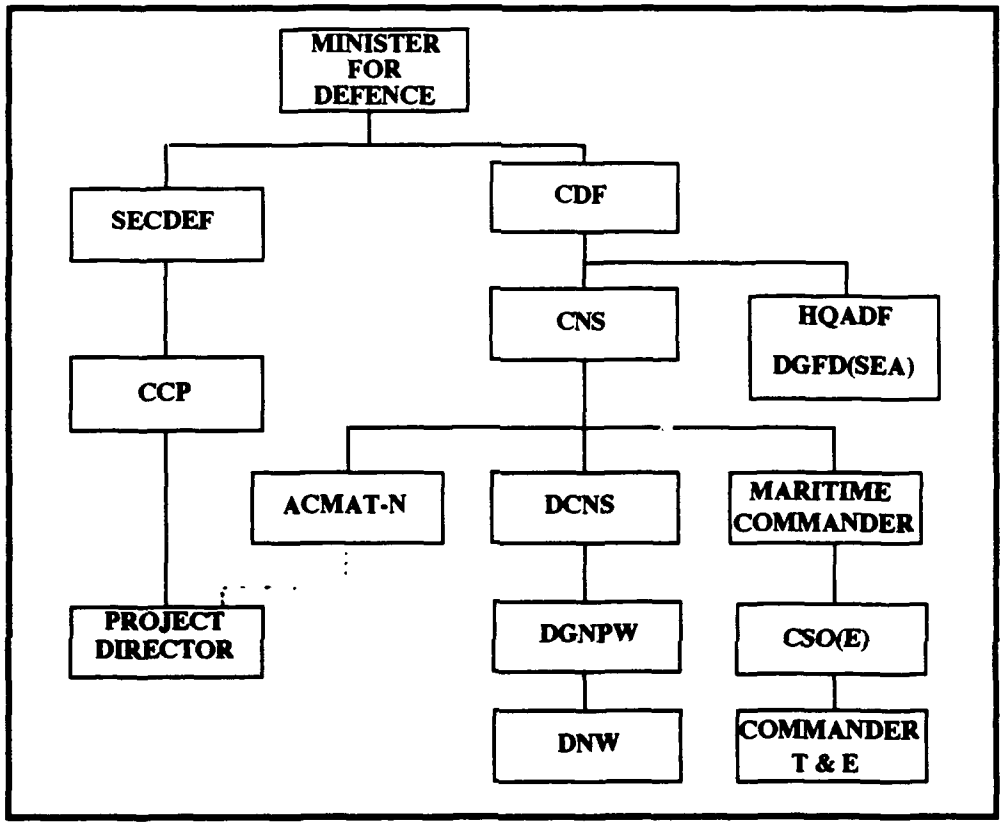

Figure 13: RAN OT&E Organisation post May 1992

So, as a result of reorganisations over the past five years, the RAN has no T&E, let alone OT&E, policy maker and overseer. It also has no OT&E coordinator within Navy Office and the RAN's OT&E authority is buried within the in-service engineering management area of the Maritime Command. The OT&E authority, however, remains independent from the developing and production agencies.

E. RAN OT&E POLICY

RAN OT&E policy is embedded in the more general T&E policy.

1. Policy Documentation

The following documents outline the RAN T&E policy:

a. Capital Equipment Procurement Manual (CEPMAN 1)

Australian DoD T&E policy has its basis in the Capital Equipment Procurement Manual (CEPMAN 1)[Ref. 38], the aim of which is to assist project managers in assessing the need for T&E in a project and to provide guidelines for its conduct. The document provides broad T&E policy and, other than defining OT&E, little policy is provided as to its conduct.

b. DI(N) LOG 82-1, RAN Test and Evaluation Policy

The top level T&E policy document for the RAN is the Defence Instruction (Navy) on RAN Test and Evaluation Policy [Ref. 44]. Its purpose is to issue policy for the conduct of T&E in capital procurement and modernisation projects in the RAN.

c. ABR 1921

ABR 1921 [Ref. 41], contains T&E and acceptance policy applicable to ships building, undergoing modernisation, conversion or extended refit. Although it refers to OT&E under PAT&E Part 2, it does not address OT&E specifically.

2. T&E Decisions

RAN T&E policy [Ref. 44:p. 2] states that the decision to subject an acquisition to T&E is initially decided by the Sponsor and detailed in the Capability Proposal. The nature and extent of the T&E is then decided by the Project Director in consultation with the Design Approval Authority and RANTAU. Any conflict

over the requirement, nature and/or extent of the proposed T&E is resolved by DCNS and ACMAT-N for operational and design matters respectively. However, in practice, the nature and extent of T&E is broadly decided by the Sponsor, and the Project Director is responsible after consultation with the DAA and the Trials Authority [Ref. 45].

3. Independence.

The independence of a testing authority is recognised in general terms in CEPMAN 1 [Ref. 38] which recognises that independent verification and validation (IV&V) is an important means of providing early detection of problems, and that it can have value and credibility. However, it implies that "independence" means independent from the Defence Department, i.e., contractors. With respect to OT&E, CEPMAN 1 compromises the independence of an OT&E authority by stating that the Design Approval Authority (DAA), which is part of the Developing Agency, is responsible for the assessment of the acceptability of the product design as a basis for Acceptance into Service. It provides for the DAA being involved in offering support to trials establishments (as required) during OT&E in order to provide DAA advice to the Project Manager on the suitability of the product for Acceptance into Service.[Ref. 38:p. 14-7] This appears to be more applicable to services other than the RAN, as the DAA within Navy does not advise the PM on the suitability for AINS.

The RAN T&E Policy DI(N) [Ref. 44:p. 3] is more clear when it states OT&E is to be conducted progressively by an authority independent of the development and production agencies (usually RANTAU). With the demise of RANTAU and the transfer of OT&E responsibilities to CTE on the staff of the Maritime Commander, independence from the development and production agencies is maintained.

4. Use of Contractors

Although the Australian definitions of OT-3 and OT-4 (Table 9) includes the requirement that the system should be demonstrated "using normal Fleet Personnel", the documentation makes no policy statement regarding contractor personnel involvement in system operation or maintenance, during OT&E. It has been RAN practice (e.g., in the DDG Modernisation Project) to have contractors onboard resolving technical problems during the SQT period, which is included as part of OT-3 in the RAN.

5. T&E Planning

The RAN uses the Test and Evaluation Master Plan (TEMP) as the single, executive, long range planning document for T&E in a project. The TEMP is to be raised in draft form as early as practicable. Based on the USN format, it is the ultimate responsibility of the project sponsor because it is the primary tool to ensure the user requirement is met. However, during the period when there is a full time Project Office, TEMP coordination is normally carried out by the T&E Manager in the Project Office. RANTAU (now CTE) as the OT&E authority provides the OT&E input. The TEMP is endorsed by all affected organisations and is released jointly by the Deputy Chief of Naval Staff (DCNS), and the Assistant Chief of Naval Staff-Materiel (ACMAT-N), as the Developing Agency. If any issues remain unresolved at this level, the TEMP will be resolved by the Chief of Naval Staff (CNS). [Ref. 44:pp. 4-5] The authority for DCNS to release the TEMP was based on his role as Project Sponsor. With HQADF now assuming this role, the DCNS function in TEMP development is unclear.

6. Combined DT&E and OT&E

Although not specifically addressed as such, combined DT&E, (PAT&E) and OT&E is implied as being condoned and almost mandatory within the RAN. The T&E DI(N) [Ref. 44:p. 3] states that OT-3 and OT-4 will incorporate the requirements of PAT-6 and PAT-7 Inspection Tests and Trials as described in ABR 1921. It also states that OT-3 will be conducted during Ship Qualification Trials. No limitations or guidance as to the possible hazards of this approach are addressed.

7. Modeling & Simulation

The use of models and simulation (M&S) in OT&E are not addressed by the RAN documentation, and their application to OT&E has been limited. Simulation and stimulation were used extensively during DT&E by both the Submarine Warfare Systems Centre (SWSC) and the Combat Data System Centre (CDSC) for the Submarine Weapons Update Program (SWUP) and DDG Modernisation respectively. However, Major combatant OT&E applications of M&S within the RAN have been limited to the DDG Modernisation Project. M&S developed by the Maritime Systems Division of the Defence Science and Technology Organisation were used by RANTAU for the evaluation of the upgraded combat and weapons systems in the Modernised DDGs.

8. Foreign Weapons Evaluation

Despite the most recent Australian Government "White Paper" on Defence Policy [Ref. 6:p. 70] requiring the need to be able to determine the performance in the Australian environment of equipment of both overseas and local origin, no DoD or RAN T&E policy specifically addresses the evaluation of foreign systems. Although, almost all of the systems procured by the RAN in recent years are

"foreign" in origin, the RAN documentation focuses on the T&E process for the progressive evaluation of locally developed systems.

9. OT&E Funding

OT&E is funded separately within a project and is estimated and bid for by RANTAU to Project Directors.[Ref. 44:p. 6]

10. Land Based Test Sites

The guidance for OT&E using land based test sites includes a statement that system centres and simulators will be employed for early stages of OT&E if available [Ref. 44:p. 4], and that OT-2 may be conducted at a land-based test site [Ref. 44:p. 3].

11. Ship OT&E

The RAN recognises that some major acquisition projects will be treated differently to others in so far as protracted construction time usually precludes T&E of a prototype before the decision to proceed to production. The degree of technical risk will be assessed in each case and, where considered sufficient, the decision taken to use land-based test sites and/or prove a particular system in another platform. When this occurs, DT-2 and OT-2 shall be conducted at the test site and the "whole ship" evaluation undertaken as soon as practicable after delivery.

F. RAN SHIP ACCEPTANCE

1. Policy

The decision to accept a new or modified ship into the RAN is vested in the Chief of Naval Staff (CNS). An Acceptance Board is established to provide an assessment of the ship and submit recommendations upon which CNS can base his

acceptance decision. The assessment of a ship leading to an acceptance decision has two distinct components [Ref. 41:p. 15.7]:

- Determining where the ship as built and tested does not meet the Agreed Ship Characteristics, contracted performance specifications and approved support standards.
- Deciding whether those Agreed Ship Characteristics, performance specifications and support standards accord with current policies standards and practices.

The Acceptance Board (AB) is an independent body established by CNS to make recommendations for CNS's acceptance into RAN service of new construction or modernised ships, submarines, aircraft. and, where directed, new systems, installations and equipment. Usually established for each new ship type and only for first of class, a Board is composed of a President, a Vice President (VP), and additional members selected from appropriate specialist areas. The President, VP and Board members serve on the Board part time. The Board is administered by the Director, RANTAU (now CTE) who is an ex officio member, assisted by a full time Secretary.[Ref. 42:pp. 1-3] The AB's sole function is to advise CNS on acceptance matters, and it is essentially a board of review.

The RAN divides acceptance into three phases:

- Preliminary Acceptance
- Acceptance into Naval Service
- Operational Acceptance

2. Definitions

The "Delivery Commissioning and Acceptance" chapter of Reference 41 provides the definitions for the acceptance process:

- "Delivery" occurs when the ship is contractually delivered from the

contractor's ownership to the Government.

- "Preliminary Acceptance" is an assessment by the RAN to determine if the ship has reached both material and support status sufficient to safely and effectively proceed with the Navy trials and evaluation program. It usually is concurrent with Delivery.
- "Acceptance into Naval Service" (AINS) signifies the acceptance of the ship as a fully operational unit of the Fleet, based on operational performance and support levels obtained at that time.
- "Operational Acceptance" is carried out only on the first of class to supplement the AINS assessment using additional operational and support experience gained with the Fleet to refine the vessel and Naval Requirements.

3. Responsibilities

Delivery of the ship to the Government is a contractual matter and is managed by the Project Director. Once delivered, the process is one of 'offer and accept' whereby the ship is offered by the Project Director to CNS for acceptance. RANTAU's responsibility is to conduct the Acceptance Trials and report the results. The Acceptance Board does not conduct tests, trials or inspections, but may witness them if required. [Ref. 42] The Acceptance Board roles are as follows:

- Be satisfied that a comprehensive and properly supervised series of inspections, tests, trials and evaluations have been carried out to the point where assessments can be made on current suitability for operational service on the basis of the approved current requirements.
- Assess the ship, aircraft or equipment, by examining reports of materiel inspections, operational trials and evaluations, attending trials as required and calling for such other tests or evaluations as necessary.
- Be satisfied that current, relevant and approved documents when promulgated describe the required operational characteristics against which the item for acceptance can be tested and evaluated for operational suitability, operational effectiveness and supportability in service.

4. Procedure

The completion process for a warship entering service is outlined in Figure 14. This process may be divided into two distinct parts:

- Those events leading to and culminating in delivery / preliminary acceptance.
- Subsequent activities leading to AINS and Operational Acceptance (if first of Class)

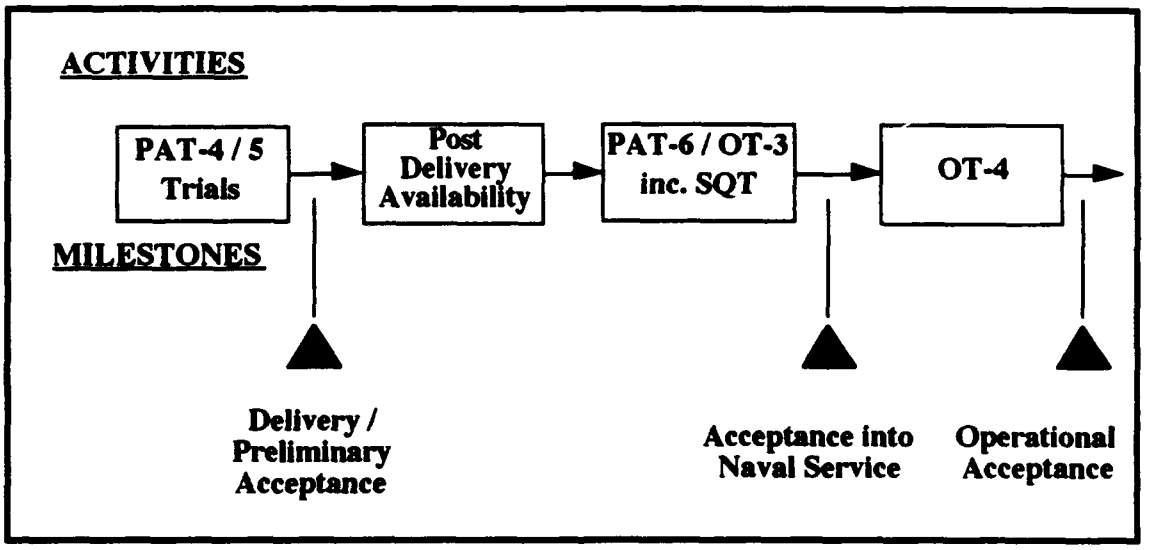

Figure 14: RAN Ship Acceptance Schedule and Milestones

a. Delivery / Preliminary Acceptance

Delivery of the ship to the Government is a contractual matter and is the prerogative of the Project Director acting on behalf of ACMAT-N and the Commonwealth of Australia [Ref. 41:p. 15.3]. Immediately prior to delivery, the AB will advise CNS whether the ship has reached a materiel and support status suitable for Preliminary Acceptance. Preliminary Acceptance assures CNS that the vessel is

considered safe for a Naval crew to take control of the vessel from the contractor and conduct outstanding RAN trials of equipment at sea or undertake specific trials for AINS assessment. [Ref. 41:p. 15.10]

b. Acceptance into Naval Service

Acceptance into Naval Service is essentially the acceptance/transfer of the ship from the acquisition part of the Navy (ACMAT-N) to the inservice operations and support areas, as having met the user requirement. The AINS assessment is carried out on completion of the Post Delivery Availability (PDA) Trials Period, at which point the ship should be in a materiel state ready for operational service. Post delivery trials leading to AINS include the SQT period, with harbour and sea elements. While the PD is responsible for the PAT&E program, RANTAU is responsible for the detailed planning and witnessing of the trials program consulting with the PD. During these trials, the PD may provide a full time trials coordinator onboard to assist the Commanding Officer and the other trials authorities.[Ref. 41:pp. 15.10 - 15.12] On completion of the trials period, the AB will advise CNS whether the materiel and support state of the ship is sufficient for it to enter service as an operational unit of the Fleet, and hence it can be accepted into naval service [Ref. 42:p. 4].

c. Operational Acceptance

For a first of class ship it will normally not be possible to trial and evaluate all aspects of the operational performance and maintainability prior to AINS without the duration of the PAT&E Part 2 program becoming excessive and because certain aspects can only be evaluated in the operational environment. This follow-on T&E period is conducted following AINS and is compiled by RANTAU in consultation with the Naval and Maritime Headquarters Staff. It comprises a series of trials and evaluations to assess operational effectiveness and operational

suitability. [Ref. 41:p. 15.14] Typical examples of these activities in the FOT&E program are:

- the evaluation of the ship as part of a force during an exercise, in order to develop standard operating procedures and tactics, and to explore the limits of capability, etc.
- evaluation of the maintainability and stores support for equipments and systems, to determine whether or not the complement, stores allowances, documentation, etc. are adequate.

Typically, the Follow-on T&E program will last from 12-24 months, depending on the class of ship. At the end of this period RANTAU compiles a report in consultation with Maritime Headquarters Staff, the ship and other authorities as appropriate, indicating:

- The results of the trials and evaluations
- Whether any changes are recommended to the proposals by the PD for correcting deficiencies which were extant at the end of PAT&E Part 2 trials.
- What additional items, if any should be added to the list of deficiencies and what action is proposed to overcome them.

The AB assesses the results and provides the overview to ensure the program is comprehensive. This assessment serves to confirm or modify the assessment at AINS.

G. RAN OT&E PROCEDURES

Procedures are the methodology by which policy is carried out. This section discusses the procedures adopted by the RAN in implementing OT&E policy.

1. User Requirement to the Acceptance Management Plan.

The development of the user requirement, and its subsequent progression through to the OT&E test documentation (Figure 15) is through the following documents:

- Operational Concept Paper (OCP)
- Defence Force Capability Proposal (DFCP)
- Required Operational Characteristics (ROC)
- Approved Ship Characteristics(ASC)
- Test and Evaluation Master Plan (TEMP)
- Acceptance Management Plan (AMP)

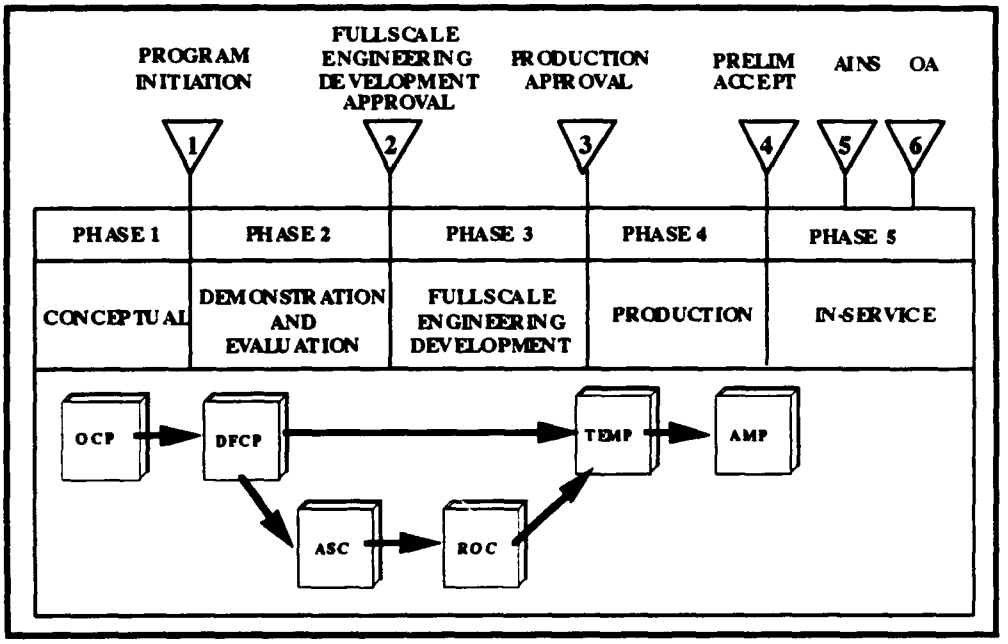

Figure 15: Progressive Definition of OT&E Documentation

a. Operational Concept Paper (OCP)

The strategic basis of papers (DOA-87 [Ref. 6] and ASP-90 [Ref. 5]) provide endorsed Government policy guidance for force structure planning. These documents identify ADF roles and establish broad priorities for capability development. From this guidance, Operational Concept Papers are produced by HQADF to identify the way ahead for specific force structure issues. [Ref. 54:p. A-4]

b. Defence Force Capability Proposal (DFCP)

Against the background of an OCP, a Defence Force Capability Proposal (DFCP) is developed by HQADF. The DFCP is the document against which specifications are produced and ultimately the proposed solution is evaluated as being suitable for service use. [Ref. 54:p. A-5]

c. Required Operational Characteristics (ROC)

To meet the overall requirements of the DFCP, more specific requirements may be described in the Required Operational Characteristics.

d. Agreed Ship Characteristics (ASC)

More detailed requirements, usually for ship programs, are developed into the Agreed Ship Characteristics (sometimes termed Approved Ships Characteristics). Other subordinate performance documentation may be developed also.

e. Test and Evaluation Master Plan (TEMP)

For a new ship design, the standards against which the ship is assessed are those derived from the then approved DFCP, ship characteristics and policies. These standards are developed into a TEMP which details the responsibilities for the specification of requirements, objectives, criteria and conduct of T&E, together with the schedule of activities, resources and key contractual dates. The most important

part of the TEMP is the statement of Critical Operational Issues (COI) which are either of high technical risk or vital to the continuing development process. These issues may not be dependent on thresholds, but should cover all areas that affect the systems capability to accomplish its mission in a combat related environment. [Ref. 44:p. 5]

f. Acceptance Management Plan (AMP)

The Trials Authority develops management plans for the trials it conducts. Where those trials lead to AINS, the management plan is termed the Acceptance Management Plan. The AMP takes the COIs from the TEMP and details the tests and trials necessary to evaluate them to support an AINS decision. Similarly a Follow on OT&E (FOTE) Management Plan may be produced detailing the trials for the OT-4 phase. The detailed trials plans are developed from these management plans.

g. Summary

As in the USN, the hierarchy of requirements documentation in the RAN provides the linkage from capability requirement to operational test program necessary to evaluate the final product against the user requirement.

2. Assessment of Operational Effectiveness

The RAN has found it difficult to define exactly what is required to assess operational effectiveness. The RANTAU guidance on the conduct of OT&E [Ref. 53] recognises that the user requirement is the bench mark for determining the degree to which a product is effective. Also that operational effectiveness is best assessed by a performance demonstration by normal operating personnel in the normal or given environment. But otherwise provides very little guidance on the assessment of operational effectiveness. Techniques employed involve analysing

each COI and employing modified Ship Qualification Trial and Fleet Exercise Program techniques to evaluate them. Use has also been made of simulation, weapon analysis and exercise analysis. The lack of suitable range facilities has also limited the assessment of operational effectiveness.

This lack of operational effectiveness assessment capability in the RAN is due to most systems being acquired from large parent Navies. Consequently, the RAN has seldom had the need to assess operational effectiveness for itself. The Submarine Project is acquiring a variety of ranges for DT&E applications, e.g., the measurement of signatures, manoeuvreing characteristics, weapon control characteristics, etc. These ranges may also be suitable to support OT&E.

3. Assessment of Operational Suitability

The assessment of operational suitability in the RAN has been controversial, particularly the assessment of supportability. This quote from the then Director of Naval Integrated Logistic Support Management [Ref. 40] in 1987 highlights a particular viewpoint:

> While there are clearly visible yardsticks by which production or weapon system performance can be measured, the success of logistic planning is to an extent invisible. Shortcomings in the assessment and provision of support will only become evident due to operational failure. All that RANTAU or the Ship Acceptance Board can do is make a subjective judgement as to whether all necessary ILS elements have been addressed and ensure that an acceptable follow on logistic support and enhancement process has been set in place.

Before 1987, the assessment of ILS, a subset of operational suitability, was rather subjective. The assessment of supportability, for example, consisted of a review of allowance lists by experienced technical specialists where potential deficiencies were highlighted. The ILS community were concerned that the onboard spares allowances developed by detailed logistic support analysis, were being

subject to a relatively simplistic, qualitative assessment. Similarly the assessment of Reliability Maintainability and Availability (RM&A) was superficial with only those defects noted during the operational assessment period (from five to seven weeks) being analysed. A new approach was taken in 1987 to the assessment of operational suitability, and to ILS in particular. The assessment process has continued to be refined with the areas in Table 11 now assessed:

TABLE 11: SUITABILITY ISSUES FOR ASSESSMENT

Suitability Issues
Availability
Reliability
Maintainability
Safety
Human Factors
Interoperability
Compatibility
Integrated Logistic Support including:
Maintenance Planning
Supply Support
Support and Test Equipment
Technical Data and Documentation
Manpower and Personnel
Training and Training Devices
Facilities
Packaging, Handling, Storage and Transport
Computer Support
Configuration Control

a. Suitability Assessment Procedure

Safety is assessed by inspection and observation during system operation. Human factors, interoperability and compatibility are assessed by

observation during operational effectiveness testing. The assessment of ILS is conducted in two phases:

(1) ILS Structural Review. Conducted prior to operational testing, this review assesses if the ILS intended to provided will support the ILS policy of the Project. It consists primarily of a review of the ILS Plan and discussions with the functional areas handling the support.

(2) ILS Operational Review. During the operational testing period, the ship's ILS related documentation and records are reviewed, maintainability demonstrations are performed and a supportability assessment is conducted. The supportability assessment still consists of a review of the allowance lists by experienced technicians, but now it also includes an analysis of spares usage and availability, from the time records are commenced to the end of the operational testing.

RM&A is assessed by the collection and analysis of data during the OT-3 phase of operational testing to give an indication of performance prior to AINS, and then continued for 12 months during the OT-4 phase. The RAN is currently developing a routine in-service RM&A data collection and analysis system, however, until that is operational, the data is collected and analysed on an 'as required' basis by the Trials Authority.

4. OT&E Reporting

RANTAU coordinates the issue of trials reports which are issued on completion of each segment of OT&E e.g., o/c ASW phase of OT-3 etc. A final trials report is issued to the AB for inclusion in their AINS report.

5. OT&E Coordination

A T&E Planning Group is formed prior to TEMP development under the leadership of the T&E manager for the project. Foundation members of the TEPG are the Project Director, Project Sponsor, the Design Approval Authority and RANTAU, with other parties seconded/called upon as required.[Ref. 44:p. 5] The TEPG analyses T&E requirements and estimates resources required to meet the requirements.

6. OT&E Personnel Selection and Training

Although OT&E is a specialised discipline with its own philosophy and methodology, the RAN has no training courses on OT&E, or on T&E in general. A number of officers have completed the USN Operational Test Directors Course in recent years which has improved the knowledge and understanding of OT&E within CTE's organisation considerably. These courses have been arranged on an ad-hoc basis through overseas visit submissions rather than as pre-requisite courses for particular billets. No special selection criteria is involved for posting OT&E personnel or project T&E managers. Although some personnel may develop into OT&E specialists, no career path is consciously provided.

H. RAN OT&E IMPLEMENTATION

The implementation of OT&E policy within the RAN maybe demonstrated by reviewing examples of ship OT&E conducted to date, and that planned for ships due to enter service in the near future.

1. DDG Modernisation Project

The RAN has three DDGs built in the USA to a modified "Charles F. Adams" (DDG-2 class) design. These ships underwent a major modernisation and

refit over the period 1987-1991. The major modernisation occurred with the ships' combat system, command and control system, sensors and weapons, with the aim of increasing the 'supportability' of the systems rather than increasing the ships' capability [Ref. 39]. The upgrade was similar to that undertaken on a small number of USN DDGs. Most of the systems were imported and installed locally, however, the combat system operational program was developed in Australia. The risk of the project failing to meet operational requirements was low, but the RAN needed to quantify the operational effectiveness and operational suitability of the modernised DDG.

OT&E consisted of an OT-3 assessment during a normal SQT period, prior to workup and the Operational Readiness Evaluation. This was followed by an OT-4 phase, termed a Combat System Evaluation (CSE), for the first of class. This OT-4 was event based and was completed over a 12 month period, integrated with the normal ships program. Procedures developed during the OT&E for the DDG Modernisation included the use of the Combat System Trainer (CST) van for simulating complex AAW engagements, the use of system modelling and analysis by the Weapons Systems Research Laboratory (WSRL), and the use of new ILS and RM&A data collection and assessment procedures.

DDG Modernisation was a low operational risk project. The OT&E followed the established RAN policy, however, it was the first to actually implement an OT-4 period to more fully assess operational effectiveness and operational suitability leading to OA.

2. Australian Frigate Project

Two US FFG-7 class frigates, known as Australian Frigates (AF), are being built in Australia. The frigates, FFG-06 and FFG-07, are being built to the HMAS DARWIN FFG-04 (USN FFG-44) configuration baseline except that the AN/SQS-

56 sonar is replaced with the Australian Mulloka sonar. Changes to the configuration were kept to a minimum commiserate with safety and operational improvements approved for incorporation into FFG-04.[Ref. 51:p. ix] All the identified equipment/ system differences between HMAS DARWIN and the AFs had undergone T&E prior to installation in FFG-05.

As the AFs have an almost identical configuration to the last FFG-7 class purchased from the U.S., the major risk was in the production, not in the operational effectiveness and suitability of the finished product, hence OT&E was limited to an OT-3 period. The objective of OT&E for the AFs is to ensure that the user requirements have been met, and to provide an estimate of operational effectiveness and suitability in the RAN operating environment prior to release of the ship to operational service. The OT&E comprises an OT-3 period, which assesses the AF against the baseline established by HMAS DARWIN, including any approved changes. [Ref. 51:p. 10] The scope of OT-3 includes a Light Off Examination, Test Procedures, CSSQT and Post PSA Trials. OT-3 is being conducted on each ship and involves:

- Installation Inspections
- Harbour Phase System Qualification Trials
- Sea Phase System Qualification Trials
- Communications System Operability Trials
- Integrated Logistic Support Assessments
- Fleet Inspections
- Air Certification
- Light Off Examination

As the significant operational difference in the AFs is the Mulloka sonar, an Operational Performance Demonstration (OPD) was planned to determine if the AF can fulfil it's ASW roles and functions with the Mulloka sonar. One week of trials was planned during the OT-3 period to ensure that the Mulloka sonar system had been correctly installed and met its operational performance characteristics. This period was found to be insufficient, primarily due to technical problems, and a "mini-OPEVAL" is now planned to quantify the system's performance.[Ref. 61:p. A-2] The acceptance schedule (Figure 16) follows established RAN policy.

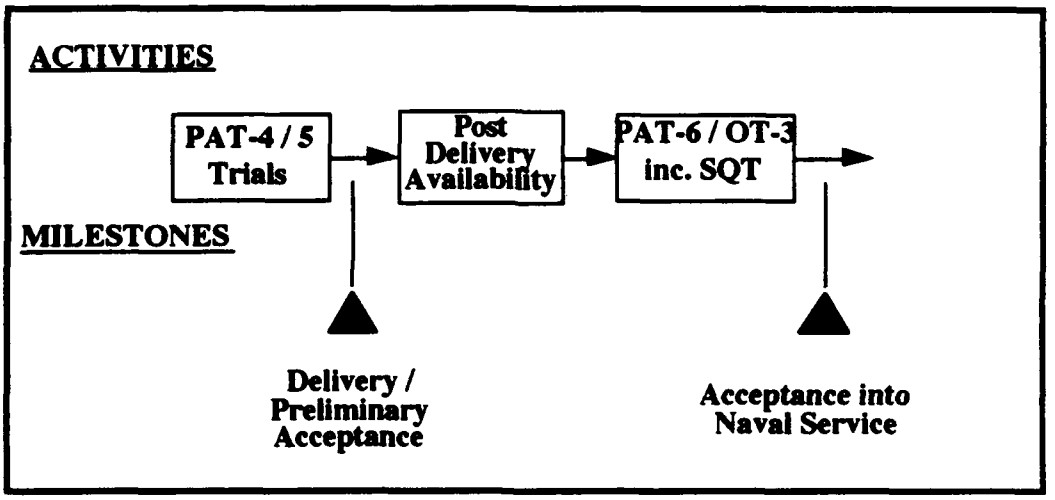

Figure 16: Australian Frigate Acceptance Schedule

The TEMP, governing all tests, trials, and evaluations up to AINS, was produced as an Australian Frigate Addendum to the U.S. FFG-7 Class TEMP. A Post Delivery Test and Trials Plan [Ref. 52] was produced to serve as an advance planning document and an implementation plan.

An Acceptance Board was established, initially for FFG-05 only. The PDT&T Plan includes the requirement that the AB is responsible for providing the Final Contract Trials agenda and conducting the trials[Ref. 52:p. 3-17], which is not in accordance with RAN AB policy. In its report at AINS, the AB considered that the application of the AB process was worthwhile and recommended that it should be followed for FFG-06, which is contrary to RAN policy of establishing the Board for first of class only. The Board also noted that acceptance documentation was contradictory and unclear. [Ref. 61:p. 2]

The AF is a low operational risk project, except for the addition of the Mulloka sonar. The OT&E followed the established RAN policy, however, it failed to plan an OT-4 period to more fully assess operational effectiveness and operational suitability of the Mulloka sonar. An OPEVAL to fully assess the performance of the sonar has now been included.

3. ANZAC Ship Project

Australia and New Zealand are cooperating in the building of the ANZAC frigate. Essentially a Blohm and Voss MEKO 200 design incorporating a combination of European and US equipment, the design is classified as low risk, although modifications to the design were necessary to meet Australian requirements and to facilitate construction in Australia. [Ref. 58]

a. ANZAC Ship OT&E

OT&E for the ANZAC ships is currently planned to include:

(1) OT-2 during which RANTAU may witness specific contractor testing, and elect to conduct initial operational evaluation using the facilities provided as part of the Combat System Support Centre, a LBTS established initially for the conduct of DT&E, and then to provide in-service system support.

TABLE 12: COLLINS CLASS POST-DELIVERY TRIALS [Ref. 59]

ITT Category (per Contract)	RAN T&E Phases	Subject of ITT / T&E
CAT 6	DT-3	First of Class Trials - Submarine 01
	OT-3	OPEVAL - Submarine 01
	PAT-6	Submarines 02 to 06
CAT 7	OT-4	Submarines 01,02 and 03 (possibly)

a. CAT 6 Testing

CAT 6 testing consists of Safety and Operational Work-ups, First of Class Trials, Operational Certification Trials, and OPEVAL.

(1) First of Class Trials (DT-3). These trials will establish the actual performance of the COLLINS design and the in-service safe operating limits and conditions for the class.

(2) PAT-6. These trials will be the Operational Certification Trials conducted after delivery in support of AINS of the particular submarine. The criteria will be based on applicable thresholds in the Agreed Ship Characteristics and the results of First of Class Trials with submarine 01. The principal events in PAT 6 include:

- Safety and operational work-up
- Manoeuvreing trials
- Weapon handling and discharge
- Combat system operation, including weapon firings
- Signature measurements

(3) OT-3. These trials are planned to evaluate the first of class only, after delivery, conducted in order that, in conjunction with the results of PAT&E Part 2, a recommendation for AINS may be made. OT-3 includes an ILS and RM&A assessment, and an OPEVAL of four to six weeks during which the submarine will be tasked to conduct a series of operations representative of the mission profiles against simulated threats and targets of interest. These trials may be reduced after experience with the first submarine.

The proposed CAT 6 schedule is detailed in Figure 17.

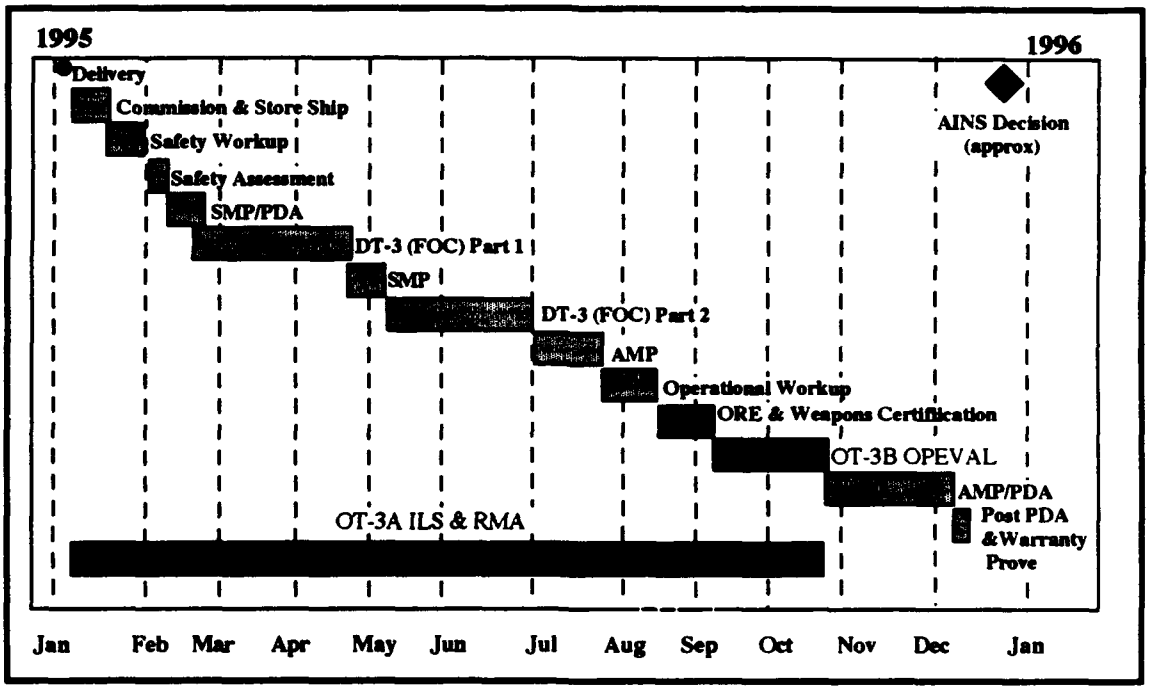

Figure 17: HMAS COLLINS - Proposed CAT 6 Schedule [Ref. 49]

Of note is that the OPEVAL is planned to be conducted following the completion of DT-3, work up and the Operational Readiness Evaluation (ORE). So it will be conducted on a materially proven and operationally worked up submarine.

b. CAT 7 Testing

CAT 7 testing, comprising OT-4 exclusively, will consist of:

(1) Long Term RM&A and ILS Evaluation. This will determine with greater statistical confidence, the Reliability, Maintainability and Availability of the submarine class, and assess the implementation of ILS items.

(2) Measures of Effectiveness (MOEs) Testing. Some MOEs will require determination by statistically significant numbers of tests. However, to minimise resource requirements the tests will be constructed to allow the total test time and asset requirements to be minimised. To accommodate other scheduling limitations, this phase will probably occur in a number of stages.

(3) Major Exercise. This phase assesses the performance of the submarine in the roles required of it during a major exercise.

(4) Operational Deployment. This phase evaluates the performance of the submarine and the support infrastructure during an operational deployment and maintenance period in a foreign port.

The proposed CAT 7 schedule is detailed in Figure 18.

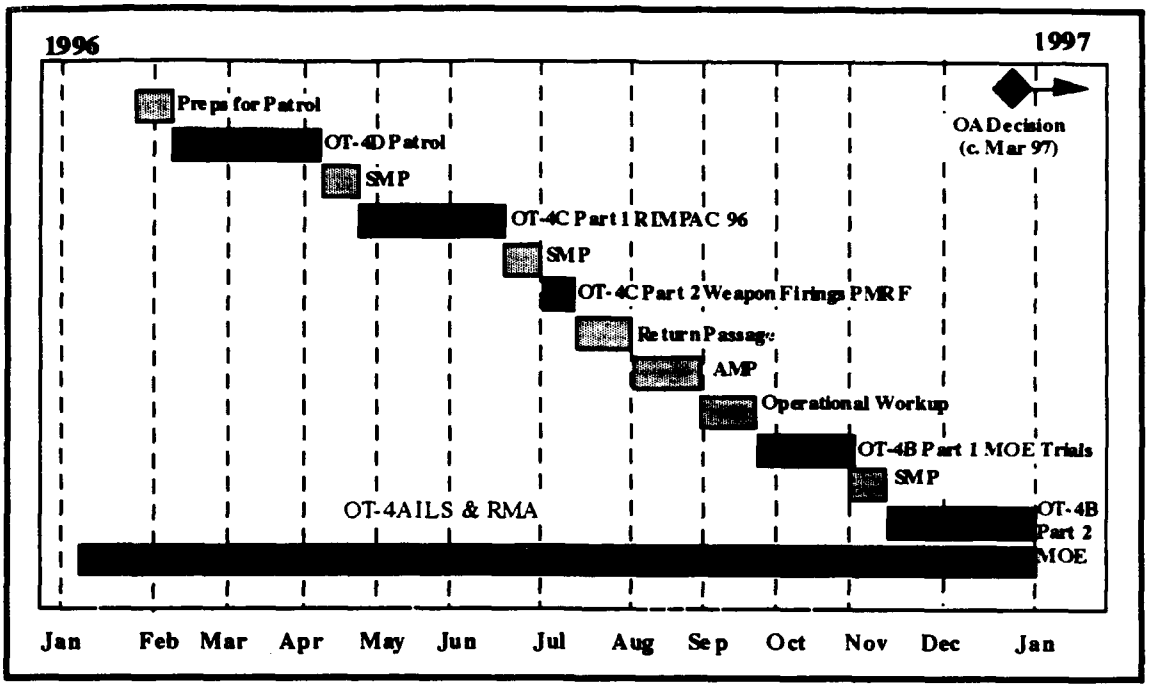

Figure 18: HMAS COLLINS - Proposed CAT 7 Schedule [Ref. 49]

c. Use of Land Based Test Sites

The submarine project includes the construction of a combat system simulator and propulsion system simulator, both for system development and training applications. Some OT&E activities may be conducted by CTE on these systems at the land based test sties on a non-interfering basis to the contractor. [Ref. 59:p. 20]

d. Collins Class Submarine OT&E Summary

Funding provision for RAN T&E up until AINS has not been included in the overall financial budgeting for the New Submarine Project [Ref. 59:p. ii]. To assist in the progressive development of the TEMP and to plan and agree those activities that will be required for AINS and OA, a TEPG has been established. The

detailed planning, preparation, execution and reporting of RAN T&E activities is the responsibility of a subordinate T&E Working Group.

The Collins class submarine possibly has the highest operational risk of all current major RAN combatant projects. Consequently the increased need for OT&E has been recognised by CTE. The planned OT&E program demonstrates a departure from the usual RAN OT&E policy, and reflects a growing awareness within CTE of the need to separate DT and OT activities, and to include a dedicated OT-3 period after the usual SQT and ORE.

5. OT&E Implementation Summary

These examples of RAN implementation of ship OT&E policy illustrates a number of key issues:

- The operational risk of ship projects within the RAN is increasing as the new RAN combatants have a unique weapons systems configuration.
- OT&E is not generally conducted to support the production or purchase decision of ships.
- The RAN relies on the results of a combined SQT and OT-3 period to provide a basis for AINS.
- ILS and RM&A assessments are becoming more effective and credible.
- Modeling and simulation is increasingly being used to assist OT&E.
- Funding of ship OT&E is not being included in original project estimates.
- Acceptance and T&E documentation is contradictory and unclear.

I. RAN OT&E ISSUES

1. What is OT&E?

Although the term "OT&E" in the RAN is defined, and the hierarchy of Defence and RAN documentation addresses OT&E, the policy for the conduct of OT&E in the RAN is not specific and is included with general T&E policy.

Combined with a lack of distinction between DT-3, PAT-6 and OT-3, this leads to the few specific OT&E policy statements often being contradictory and unclear.

a. Independence of the OT&E Authority

OT&E is specified in RAN T&E policy [Ref. 44:p. 3] as being conducted by an authority independent of the developing and production agencies, and the results of OT-3 support an AINS decision. However, CPO Manual [Ref. 38:p. 14-7] states that the Design Approval Authority (part of the developing agency) offers support to trials establishments during OT&E in order to provide advice to the Project Director on the suitability of the product for Acceptance into Service. This leads to conflicts between the DAA and the Trials Authority during the conduct of OT&E.

b. Confusion between DT-3, PAT-6 and OT-3

RAN T&E policy [Ref. 44:pp. 2-3] explains the T&E phases in the procurement process and then includes a note stating that OT-3 and OT-4 will incorporate the requirements of PAT-6 and PAT-7 Inspection Tests and Trials as described in ABR 1921(Reference 41). ABR 1921 however, defines many tests as being PAT&E, that RANTAU [Ref. 43] define as OT&E. Also DT-3 is shown as being conducted during the same period, however, the philosophy, aims, objectives and methodology of DT&E, PAT&E and OT&E are totally different. Perhaps this overlap or "blurring" of definitions arose because RANTAU was not only the RAN OT&E authority, but also the RAN T&E authority who conducted aspects of DT&E and PAT&E in addition to OT&E. With a large part of its workload devoted to conducting trials following the routine refit of combatants, RANTAU conducted HATS and SATS which were understood to be PAT&E and then went on to conduct the more operational Ship Qualification Trial (SQT) which was perceived to be OT&E. The SQT period, however, is rarely a free play environment, makes limited

use of countermeasures, and is conducted prior to the crew being fully worked up. Also contractors are often still onboard making final adjustments to systems and assisting the crew with operation and/or maintenance. The SQT is essentially a PAT&E function which may include some components of the operational effectiveness and suitability aspects of OT&E.

The problem with this "blurring" of definitions goes beyond the semantics. The results of OT-3 are used to support an AINS decision, but as it is really PAT&E, it assesses more the ability of the ship to meet technical or Fleet standards. It does not truly assess the operational effectiveness and operational suitability of a new ship against the user requirement. Therefore, a ship is not truly subject to OT&E against the user requirement before it is granted AINS.

This lack of distinction between T&E types also confuses Project Directors and other Defence managers. It leads to a lack of consideration of the importance of OT&E, and hence the need to consider OT&E funding early in a Project. It also leads to confusion over T&E management responsibilities. It confuses the role of the Acceptance Board, which is really assuming a quality control function over what is essentially PAT&E testing, rather than it's members using their knowledge and experience in assessing the results of true OT&E against the user requirement.

The difference in terminology used by different documents and authorities also creates confusion. For example, the term OPEVAL is defined [Ref. 38:p. 14A-2], but terms such as mini-OPEVAL [Ref. 61], Operational Performance Demonstration [Ref. 51] and (Ship) Operational Trials [Ref. 41][Ref. 44] are not.

2. OT&E and Acceptance of New Combatants

With the construction of new frigates and submarines, the RAN has embarked on its greatest shipbuilding program since the Second World War.

Although these combatants are being built to proven designs and, therefore, are considered relatively low risk, they do present a greater operational risk than recent RAN combatant programs. In September 1991, CNS expressed concern that the RAN "may not be adequately placed" to properly manage the comprehensive and complex procedures necessary to accept the ANZAC ships and Collins class submarines into service [Ref. 62]. This has focussed attention on the acceptance procedures and consequently on the OT&E of the new combatants.

3. The New RAN OT&E Organisation

RANTAU ceased to exist as an organisation on May 15, 1992. The rationale leading to this decision is important as it is indicative of the level of understanding of OT&E within the RAN.

a. Background

RANTAU was established in 1966, and originally administered by Navy, but later by the Defence Scientific and Technical organisation. In 1982 control of RANTAU was returned to Navy with the stated purpose of conducting operational testing and evaluation, conducting inspections and providing operational assessment data.[Ref. 46:p. 1] Functional and operational responsibility for RANTAU was transferred from the DCNS Division of Navy Office to the Maritime Commander on 31 July 1991 concurrent with the introduction of the Program Management and Budgeting System(PMBS). The Director of RANTAU was made responsible to the Maritime Commander for the management of RANTAU.

b. What Did RANTAU Achieve?

As a result of this change in the organisational structure (a change due fundamentally to financial funding and accounting requirements) there was a need

to question what RANTAU achieved overall, and whether its tasking should be amended to more accurately reflect the needs of the Maritime Commander in maintaining, and where necessary improving, the operational capability of the Maritime Force. A study was directed [Ref. 46] to:

- focus on the tasks required to be undertaken to assess the operational effectiveness of Maritime Force units and the Force as a whole.
- study any aspects of RANTAU's current employment which were inappropriate given its functional and operational responsibilities to the Maritime Command.

The results of this study [Ref. 47] found that only about 20% of the work carried out by the RANTAU Trials Unit was carried out for the Maritime Commander. This consisted of SQTs, and HATS and SATS. The large majority (80%) of the work done by the Trials Unit was found to be done on behalf of the Assistant Chief of Naval Staff - Materiel (ACMAT-N) in accordance with ABR 1921(Reference 41). The report stated that the work conducted for ACMAT-N included:

- assisting with the writing of the TEMP for every project.
- installation inspections as part of PAT&E Part 1.
- heavy involvement with PAT&E Part 2.
- the conduct of OT&E for most projects.
- support for the post delivery acceptance into Naval Service (AINS) process.[Ref. 47:p. 17].

c. Organisation Options

The report proposed transferring the Trials Unit, less a proportion to support Fleet Trials, to the Materiel Division. The unit would then be ideally situated to form the nucleus of an organisation with responsibility for the coordination and administration of all trials conducted for and/or by the RAN. It could also form the

core of the AB, with perhaps the Director being the standing vice president of the body.

The Materiel Division rebutted this argument with the perception that an independent audit authority is necessary to maintain production standards. It appears that there is a belief that if the RAN's trials authority was to be a functional unit of the Materiel Division, then the head of the Division would be able to influence trials results. The report contends that this argument appears to point to a management problem rather than a structural issue, but in any case it did nothing to counter the argument that the RANTAU Trials Unit is not an appropriate component of the Operations Sub-program of the PMBS (i.e., the Maritime Command). A solution to this problem would be to return the Trials Unit to the Executive Sub-program (i.e., Navy Office). However, it recognised that the service provided by the trials authority was also largely unrelated to that sub-program. The report then considered the impact of HQADF, who occasionally tasks RANTAU in support of *projects for the development of the maritime component of the* ADF.

The report recognised that this seemingly simple organisation of RANTAU was, in fact, complex due to the variety of tasks imposed upon the unit by a number of masters on a day to day basis. It concluded that as a single unit, RANTAU does not rest comfortably with the current arrangement and nor does it with any other Navy Sub-program for budgeting and management purposes.

d. An "Audit" Function

The report states that RANTAU served an apparent independent audit function for the Materiel Command, and that:

> this function was something that had evolved over time rather than in response to any specific need. It was beyond the scope of the original purpose for the organisation which became RANTAU, and the absolute need for such an audit service in the era of PMBS and tight fiscal control is questioned. An audit

service for the Materiel Division does not seem an appropriate sub-component for the Combat Forces sub-program.

The report concluded that, other than for a small trials unit to conduct trials in support of units assigned to the fleet, it is inappropriate for the Maritime Commander to have functional and administrative control of a Trials Unit which largely serves the Materiel Division. The options appeared to be the transfer of the Trials Unit to the either the DCNS or Materiel Divisions.

e. The OT&E Function

The report, however, failed to recognise that RANTAU was the OT&E authority. As such, the "audit" work apparently done for the Materiel Command was really done on behalf of the sponsor (i.e., HQADF) and the user (i.e., the Maritime Command), as OT&E is the final feedback that the item produced by the Materiel Command meets the user requirement.

f. Current Trials Organisation

Following the release of this report, and due to the RAN's decision not to adequately staff and fund RANTAU as an independent unit, the functional tasks of RANTAU were incorporated within the framework of the Maritime Headquarters [Ref. 48]. The current placement of the former Trials Unit, now known as Commander Test and Evaluation, within the Maritime Command is shown in Figure 19. Of note is that the OT&E authority is now responsible to the Maritime Commander through the in-service engineering management chain of command.

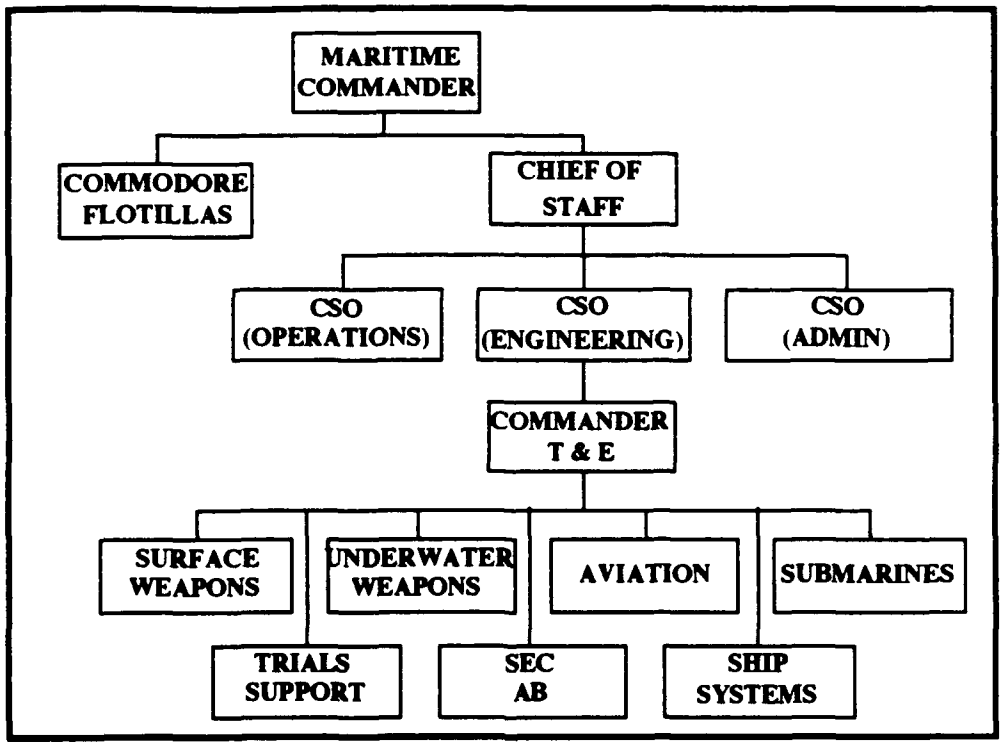

Figure 19: Commander Test and Evaluation Organisation

J. SUMMARY

1. Importance of OT&E

The importance of T&E in general is recognised in the acquisition process, to identify problem areas, to allow timely corrective action to be taken, and to reduce technical risk. As Australia has a policy of procuring low risk, operationally proven systems, which may be constructed locally, rather than higher risk local development, the RAN concentrates on post delivery testing, rather than testing to support a production or purchase decision. The importance of OT&E to the acquisition process, however, is not adequately appreciated. The RAN appears to

have its focus on PAT&E to meet technical and fleet standards, rather than an assessing operational effectiveness and operational suitability against the user requirement.

2. OT&E Policy

The lack of emphasis given to OT&E within the RAN is possibly due to the lack of clear guidance on OT&E in the T&E policy documentation. The decision to subject an acquisition to T&E will initially be decided by the Sponsor and detailed in the Capability Proposal, however, the Sponsor and other acquisition managers require clear guidance on T&E to enable them to make effective decisions. The categories of ship T&E used in the Australian DoD have been derived from the U.S. DoD instructions, but interpreted to accord with Australian Requirements. During this interpretation there has been a "blurring" of the types of T&E, resulting in a lack of clear delineation between the T&E types. This problem was further compounded by the adoption of the PAT&E based, USN Total Ship Test Program system, and modifying it to include DT&E and OT&E components.

3. RAN OT&E Organisation

The RAN and DoD have reorganised over the past five years to create a more effective and efficient user requirements organisation, and to better accord with Program Management and Budgeting principles. However, as a result, the RAN has no T&E, or OT&E policy maker and overseer, no OT&E coordinator within Navy Office, and the RAN's OT&E authority is buried within the in-service engineering management area of the Maritime Command.

4. Understanding of OT&E

As a result of incomplete, contradictory and confusing T&E policy documentation, emphasis on PAT&E and the "blurring" of T&E types, the lack of

true OT&E actually conducted and few personnel experienced in OT&E, the understanding of OT&E within the RAN is poor. As a consequence, the philosophy, methodology, and benefits to the RAN of OT&E are not adequately recognised.

5. Summary

The demise of the RAN's independent OT&E authority, RANTAU, and its subsequent integration within Maritime Headquarters as the Commander, Test and Evaluation (CTE), was the latest in a series of reorganisations that has significantly reduced the capability and authority of the OT&E community. The new combatants currently under construction for the RAN, although relatively low risk by USN standards, are a higher operational risk than previous RAN ship programs. Although using proven technologies, both the ANZAC ships and Collins class submarines have unique weapon and sensor fits, not currently in service with large parent navies. The conduct of PAT&E only, is not considered sufficient to measure the operational effectiveness and suitability of these new combatants to determine, with confidence, that they meet the user requirement. This can be achieved by the conduct of an effective OT&E program.

V. USN / RAN OT&E COMPARISON

This chapter compares the characteristics of the USN and RAN OT&E systems and highlights significant differences.

A. DEFENCE ACQUISITION PROCESS

The Defence system acquisition life cycle of both nations consists of progressive development phases separated by major decision milestones. Milestones are periodic formal program reviews for authorisation to advance to the next stage. The two systems are compared in Figure 20. With a policy to maintain world leadership in key Defence technologies, the U.S. places priority on development programs. The major decision point is centred on the decision to proceed beyond Milestone IIIA - Low Rate Initial Production , when the large dollars in an acquisition program are due to be spent in the production phase. Passing a formal, independent OPEVAL is its major criterion for approval to Full Rate Production.

Although the decision to produce or purchase a new system is important, the Australian DoD prefers lower risk, proven technologies for the majority of new Defence acquisitions. In many cases, systems with the fundamental capabilities required by the ADF are available overseas, however, some of these systems require additional development, adaptation or integration to meet Australian specific requirements. The Australian system, therefore, places a high priority on the post production phase with the three milestones of Preliminary Acceptance (PA), Acceptance into Naval Service (AINS) and Operational Acceptance (OA). However, Australia is now buying far less "off the shelf" from overseas, and

systems are increasingly being designed and built in Australia, or at least adapted from overseas designs.

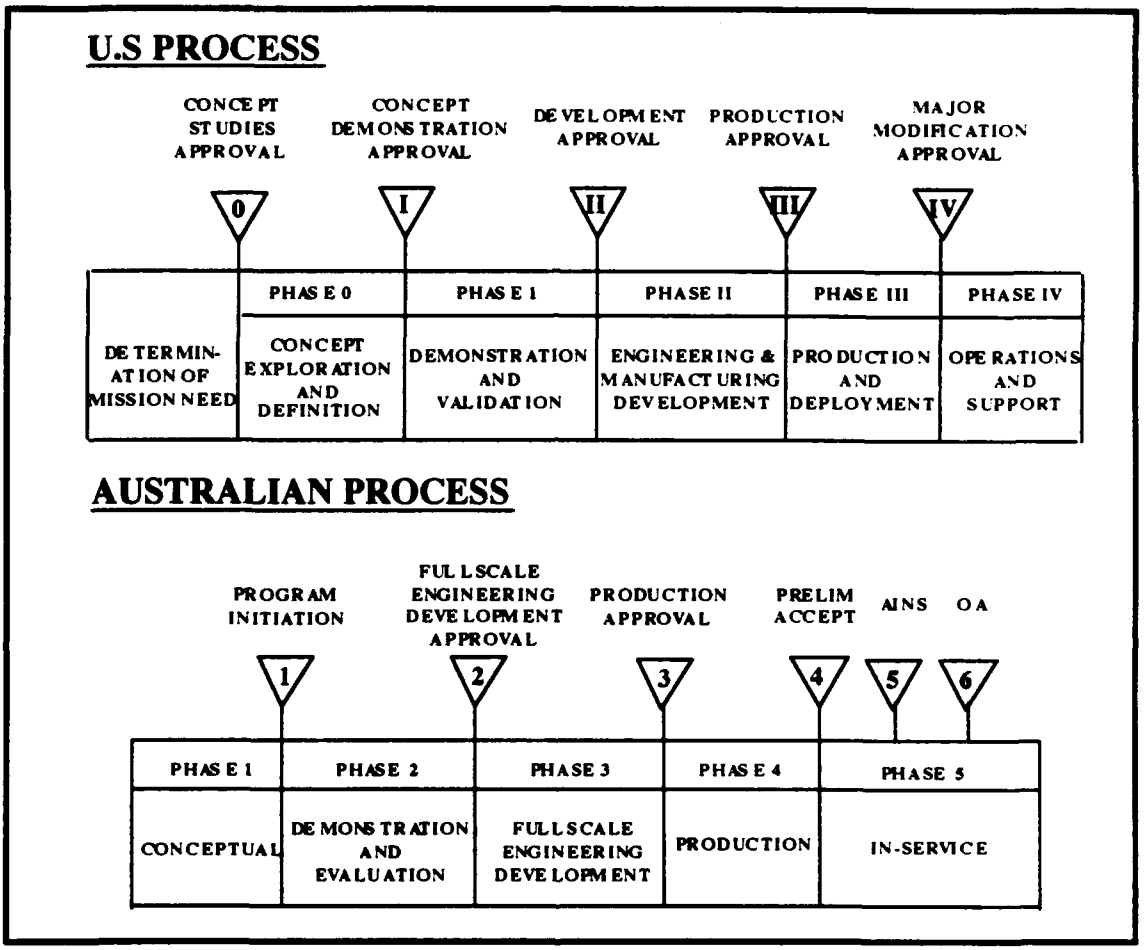

Figure 20: Comparison of U.S. and Australian Acquisition Processes

B. T&E DEFINITIONS

Definitions and terminology form the basis of a T&E system. As the categories of ship T&E used in the Australian DoD have been derived from the U.S. DoD instructions, both Navies recognise three types of T&E:

- Developmental Test and Evaluation (DT&E)
- Production Acceptance Test and Evaluation (PAT&E)
- Operational Test and Evaluation (OT&E)

The categories within these types of T&E, however, have been interpreted by the RAN to accord with Australian requirements [Ref. 38:p. 14-1]. This interpretation leads to some subtle, but significant, differences in T&E definitions between the two Navies.

1. Developmental Test and Evaluation (DT&E)

DT&E is conducted to assist the engineering design and development process and to verify attainment of technical performance specifications and objectives [Ref. 11:p. 3]. Both Navies agree that DT&E is conducted in three major phases. Table 13 compares these DT&E phases. Minor wording differences aside, the three DT&E phases are essentially identical. The most significant difference is that the USN recognises PAT&E as a form of DT-3 testing.

TABLE 13: COMPARISON OF DT&E PHASES

USN Description	DT	RAN Description
Demonstration that all technical risk areas have been identified & that best technical approaches have been accepted.	**DT-1**	Validation of design concept.
Demonstrate that design meets specifications.	**DT-2**	Proving design.
Testing conducted on production items to ensure compliance with contracted specifications. **PAT&E is a form of DT-3.**	**DT-3**	Demonstration that production meets required technical characteristics.

2. Production Acceptance Test and Evaluation (PAT&E)

Both Navies agree that PAT&E is testing conducted on production items to ensure systems meet contract specifications and requirements. PAT&E for ships in the USN is managed under the Total Ship Test Program (TSTP) which includes seven phases of PAT&E. In recent years the RAN has adopted the TSTP, initially with the modernisation of the DDGs, and now in the testing of the locally produced FFG-7 class under the Australian Frigate Project. The adoption of the TSTP by the RAN included the redefinition of the test phases. A comparison of the PAT&E phases is provided in Table 14. There are major differences between the two Navies in these PAT&E categories. The USN system includes only PAT&E, whereas the RAN includes elements of DT&E and OT&E, in addition to PAT&E, and they are given PAT designations.

TABLE 14: COMPARISON OF PAT&E PHASES

USN Description	PAT&E	RAN Description
Not defined in U.S. system	**PAT-0**	Design and engineering development tests
Material receipt inspection and shop tests	**PAT-1**	Production and burn-in tests
Shipboard installation inspections and tests	**PAT-2**	Environmental qualification tests
Equipment level operational tests	**PAT-3**	System development tests
Intrasystem tests	**PAT-4**	Harbour testing
Intersystem tests	**PAT-5**	Sea testing
Special tests e.g., surveys, rangings	**PAT-6**	Operational and Qualification Trials (conducted with OT-3)
Trials tests including sea trials, builders trials, acceptance trials.	**PAT-7**	Follow on Operational T&E (conducted with OT-4)

3. Operational Test and Evaluation (OT&E)

Both Navies concur that OT&E is conducted to determine a system's operational effectiveness and operational suitability, to identify system deficiencies and the need for potential modifications to meet established OT thresholds, and develop tactics. They also agree that OT&E has three distinguishing characteristics:

- It is conducted in an operationally representative environment
- It is conducted on production representative equipment using fleet personnel for operation and maintenance.
- It is conducted against a threat-representative simulated enemy carrying out threat tactics per the latest threat assessment.

They both use the term "Operational Evaluation", abbreviated as "OPEVAL" to cover T&E on production representative baseline equipment using the maintenance and support personnel and equipment for normal operational use which aims to:

- Demonstrate operational effectiveness and suitability.
- Provide data to assist in the development of tactical aspects of the equipment.
- Verify data, handbooks and documentation covering the operation of the system.

The USN uses the term OPEVAL as the final stage of OT-II, supporting a production decision. Although the Australian definition of OT-2 includes an OPEVAL, the term is not used exclusively for OT-2. It is used in many contexts from OT-2 to OT-4.

There are also significant differences in the detailed OT&E definitions. The RAN includes ship Certification / Qualification trials in OT-3, whereas the USN categorises Certification trials as PAT&E and Ship Qualification Trials (SQT) as regular in-service PAT&E conducted by the INSURV Board and Type Commander.

not as OT&E. A comparison of the OT&E phases of the USN and RAN are given in Table 15.

TABLE 15: COMPARISON OF OT&E PHASES

USN Description	OT	RAN Description
Early Operational Assessment	**OT-1**	Operational assessment of the development proposal
OT&E conducted to support a production decision. Final phase is termed **OPEVAL**.	**OT-2**	Demonstration of achievement of program requirements for operational effectiveness and suitability of a prototype (**OPEVAL**) to support proceeding to full production
OT&E conducted on production system to verify correction of deficiencies after OPEVAL, and certification of operational effectiveness and suitability.	**OT-3**	Demonstration of achievement of program requirements for operational effectiveness and suitability on production of ship/aircraft/system, normally in independent operations using normal Fleet personnel. **Certification/Qualification Trials** include limited reliability, maintainability, availability and logistic supportability assessments.
Validation of the operational effectiveness and suitability of production systems. Usually in different environments and to assess integrated operation of system. For ship programs, is normally conducted to verify that critical deficiencies have been identified and to complete any outstanding OT&E.	**OT-4**	Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/ aircraft/system using normal Fleet personnel in a multi-force, multi-threat environment, Includes detailed reliability, maintainability, availability and logistic supportability assessments.
Not defined in the U.S. System.	**OT-5**	Follow-on OT for assessment after modernisations, new applications or defect rectifications after OT-4

C. T&E IN THE ACQUISITION PROCESS

Both Navies appreciate the importance of T&E in the acquisition process. T&E results are assessed as part of the milestone reviews. However, the level of importance of T&E, and OT&E in particular, differs greatly.

1. The Requirement for T&E

The importance of T&E, and OT&E in particular, to the progressive assessment of programs in the USN is such that its use has been mandated by the U.S. Congress and incorporated into the laws of the United States. The law includes the provision of a Director of Operational Test and Evaluation (DOT&E) in the Department of Defence. The law also addresses specific areas of OT&E reporting and conduct to ensure the Congress is kept informed, and the testing and reporting are impartial [Ref. 17]. By including the requirement that a major Defence acquisition program may not proceed beyond low-rate initial production until initial OT&E of the program is completed, Congress ensures that OT&E is an integral part of the acquisition process.

The USN appreciates that, if adequate OT&E is not done, and the weapon system does not perform satisfactorily in the field, significant changes may be required. Moreover, the changes will not be limited to a few developmental models, but may also be applied to items already produced and deployed. The USN also recognises that, in extreme situations, it also risks deploying systems which cannot adequately perform significant portions of their missions, thus degrading its deterrent / defensive capabilities and endangering the safety of military personnel who operate and maintain the systems.

The need for local T&E is recognised by the Australian Government and DoD, for both indigenous and overseas systems, however, the importance of OT&E in particular, is not specifically addressed in any Australian T&E policy document.

Perhaps this lack of recognition of the importance of OT&E is due to the RAN procuring low risk, complete ships in the past (e.g., FFG-7 class) with the wealth of USN DT&E and OT&E behind it. Also the RAN, unlike the USN, has not experienced the operational situations in recent years which may have highlighted operational effectiveness and suitability deficiencies in its ships. With the RAN now buying higher risk, unproven combinations of systems within its ships, it must now rely on its own OT&E.

2. T&E Contributions At Major Milestones

The USN OT&E system forms an integral part of the acquisition process. Program advance from one phase to the next is not by the calendar of planned schedule, but by actual resolution of critical operational issues and achievement of pre-set thresholds verified by T&E [Ref. 11:p. 2]. OT&E in the RAN, on the other hand, may be conducted during each phase in the acquisition process, but it is not essential to a local system meeting a development or production milestone, or the local production or purchase decision of an overseas system. It is however, required before a system achieves Acceptance into Naval Service or Operational Acceptance. Figure 21 compares the contributions of T&E to the acquisition milestones for each Navy.

Although the diagrams appear to be very similar, the RAN OT&E contributions to the acquisition milestones are by no means definitive. There is no documented requirement for the conduct of OT-1 and / or OT-2 prior to a production or purchase decision of major acquisitions. The decision to conduct OT&E being the responsibility of the Sponsor, Project Manager and the Defence acquisition committees. RAN T&E policy documentation almost exclusively focuses on the post production acceptance phases. Even during the acceptance phase, however, the

requirement for OT-3 is clouded in definition differences between policy documents. The RAN appears to have its focus on PAT&E.

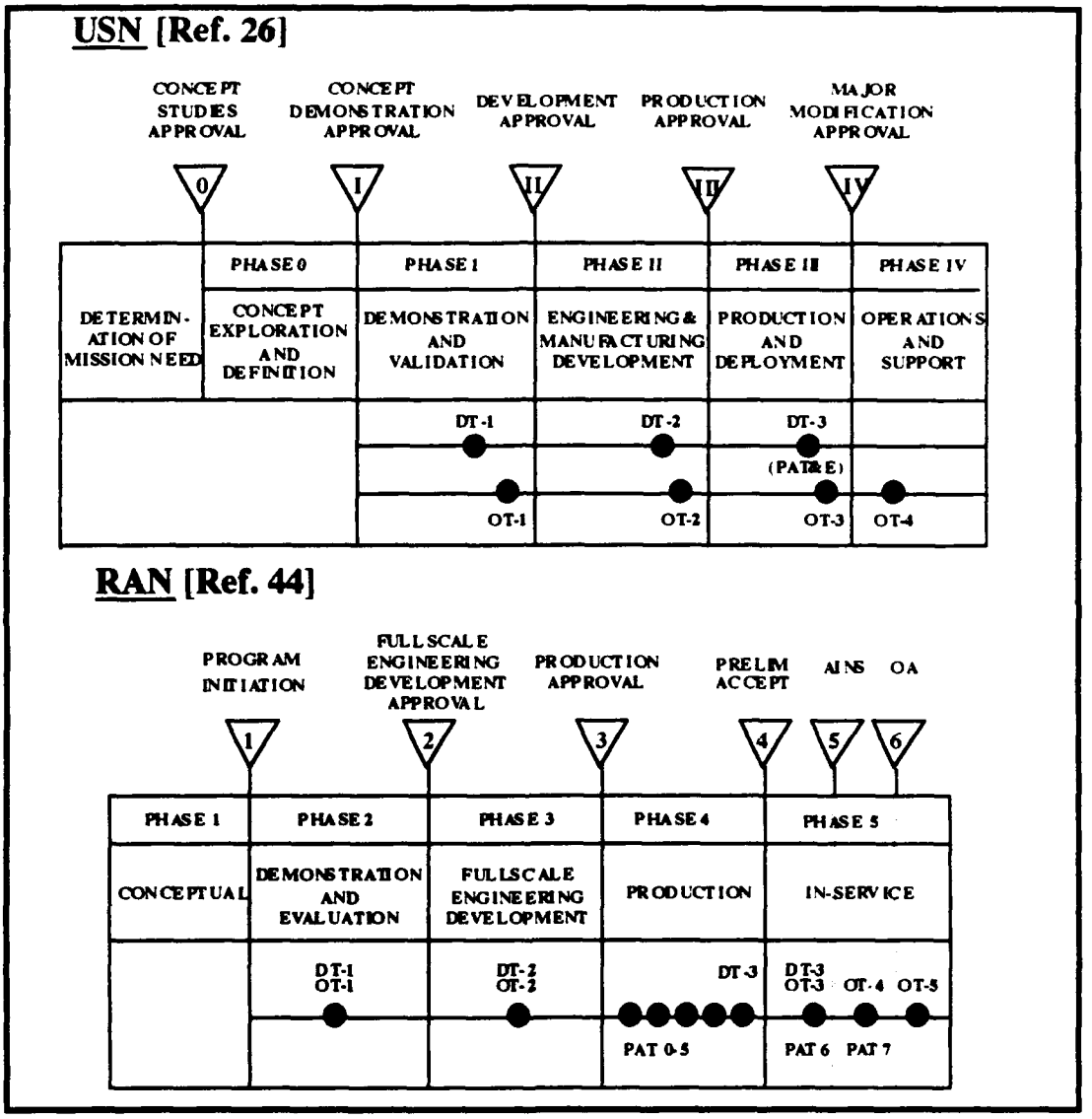

Figure 21: Comparison of T&E Contributions to Acquisition Milestones

Of note is that the USN diagram shows separate activities for DT&E and OT&E related tests, while the RAN diagram groups them all together. This demonstrates the delineation between DT&E /PAT&E and OT&E evident in the USN system.

D. OT&E ORGANISATION

The OT&E organisation consists of a number of functions. The authorities performing these functions in each Navy are listed in Table 16.

TABLE 16: COMPARISON OF OT&E AUTHORITIES

USN Authority	OT&E Function	RAN Authority
Director, Operational Test & Evaluation (DoD)	**Policy Maker & Overseer**	Nil
N8 - Warfare Requirements Chief of Naval Operations	**Sponsor**	Director General Force Development (Sea)
Commander, Naval Sea Systems Command	**Developing Agency**	Assistant Chief of Naval Staff - Materiel
Commander, Operational Test and Evaluation Force	**OT&E Tester & Evaluator**	Commander, Test & Evaluation
Ships Commanding Officers, Fleet Commanders	**User**	Ships Commanding Officers, Maritime Commander
Director, Test, Evaluation & Technology Requirements	**OT&E Coordinator**	Nil

1. OT&E Policy Maker and Overseer

An OT&E policy maker and overseer is employed in the U.S. system responsible for policy formulation, evaluation and oversight of all OT&E. The Director of OT& E (DOT&E) is the principal OT&E official in the Department of Defence and the principal advisor to the Secretary of Defence on OT&E. In addition, a Director T&E, responsible for developmental testing policy reports, to the USD(A) in DoD.

There is no clear OT&E, or T&E, policy maker or overseer within the Australian DoD or the RAN. The Chief of Capital Procurement [Ref. 38] addresses T&E in general, but more in the form of guidance rather than policy. The former Director General of Naval Warfare (DGNW) drafted the RAN Test and Evaluation Policy Defence Instruction [Ref. 44], however after the recent reorganisation, T&E policy for the RAN is presently in a state of flux, with no office having assumed the responsibility [Ref. 50].

2. Program Sponsor

The program sponsor is responsible for the development of concepts for operations for naval warfare systems, and for acquisition program requirements and related system thresholds. He/She is also responsible for the subsequent trials and continuing overview to ensure that the equipment meets the requirement. Within the USN, major warship programs are sponsored by N8 - Warfare Requirements, under CNO. Under the new USN organisation, increasing importance is given to the Fleet and Type Commanders in determining requirements and allocating priorities. Besides generating the user requirement, the sponsor also has a review function in the OT&E process.[Ref. 20]

The Australian Defence Force has a centralised force development and user requirements organisation. within HQADF, the Director General Force

Development (Sea) having sponsorship of major RAN acquisitions. The decision to subject an acquisition to T&E in the RAN is initially decided by the sponsor and detailed in the capability proposal [Ref. 44:p. 1].

3. Developing Agency

When a program is approved, a program office is formed to manage the acquisition of the system. In the case of the USN, this office is established within the Naval Sea Systems Command (NAVSEA). The program office is responsible for the conduct of DT&E in preparation for OT&E. To assist all NAVSEA programs with T&E matters, NAVSEA have established their own T&E office (SEA 60). Although primarily a DT&E policy authority, this office also has an input into the OT&E process by reviewing the TEMP, and by conducting OT&E readiness reviews of NAVSEA programs.

Within the RAN, the Materiel Division is responsible for acquisition of the capital equipment to meet the requirement. Similar to the USN, the nature and extent of the T&E to be conducted is decided by the Project Director in consultation with the Design Approval Authority and RANTAU. However, the Materiel Division does not have a T&E office to support Project Directors.

4. OT&E Tester and Evaluator

The Operational Test and Evaluation Force (OPTEVFOR) is the USN's sole independent test agency responsible for the planning and conduct of OT&E. COMOPTEVFOR reports directly to the CNO, and is separate and distinct from the developing and procuring commands.

The RAN Trials and Assessing Unit (RANTAU) was the RAN's OT&E authority who also conducted DT&E / PAT&E on behalf of Project Directors and Ship Qualification Trials for the Maritime Commander. With the disestablishment of RANTAU in May 1992, these trials functions were transferred to the Commander,

Test and Evaluation (CTE) under the Chief Staff Officer (Engineering) in the Maritime Command.

5. User

The Commanding Officer and crew of the ship under test, and his Fleet and Type Commanders are the ultimate users of the system. The Maritime Commander, and the individual ships' Commanding Officers and crews are the ultimate users of a ship. The personal assessment of the Commanding Officer of the ship under test is sought by OPTEVFOR during the conduct of OT&E [Ref. 15:p. 44]. The Commanding Officer of a ship under test usually provides CTE with his opinions on the ship's performance at the conclusion of a trials period.

6. Coordinator

CNO has responsibility for ensuring the adequacy of the Navy's overall test and evaluation program. T&E policy and guidance are exercised through the *Director, Test, Evaluation and Technology Requirements (N091)*. This organisation also acts as a T&E Focal Point and Coordinator, responsible for coordination of T&E matters in the designated Programs, System Commands and Department of the Navy. [Ref. 13:p. 7-5]He also chairs the Test and Evaluation Coordination Group The RAN currently has no authority with this role, however, the T&E manager within major projects is responsible for chairing the Test and Evaluation Planning Group.

7. OT&E Organisation Summary

A comparison of the OT&E organisation structures of both Navies is shown in Figure 22. The USN OT&E organisation is well structured with comprehensive responsibilities for each participant, and clearly delineated from the DT&E structure. COMOPTEVFOR is the truly independent tester and evaluator, being

separate from developing, production and user agencies, and responsible only for OT&E. As a Rear Admiral and reporting directly to the CNO, he has authority, visibility and influence. The office of DOT&E provides a layer of oversight on the OT&E process to ensure objective testing is conducted, giving credible results and leading to impartial decisions. NAVSEA has its own T&E agency to assist PM's in DT&E, and in preparation for OT&E. The OT&E process is coordinated from within CNO's office by the Director, Test, Evaluation and Technology Requirements.

Following a number of recent reorganisations, the RAN's OT&E structure is in disarray. The RAN's OT&E authority is now CTE within the Maritime Command. In addition to OT&E responsibilities, he also conducts some DT&E, and some functions equivalent to the USN INSURV board, OPTEVFOR and the Type Commander. Only of Commander rank, he lacks authority, particularly with Project Directors and, being within the in-service engineering area, he possibly lacks credibility and influence on operational matters pertaining to OT&E. In developing programs, the RAN relies on the minimal interface between the centralised sponsor (DGFD(Sea)) and CTE to ensure appropriate OT&E is considered, since the sponsor has no agency within his own organisation to provide the necessary advice. Once a project is established, the Project Director performs the coordinating role through the TEPG. The Materiel Command, however, has no T&E agency to advise PD's on this role, and to be the retainers of "lessons learned" from other projects. Finally, with no clear policy maker for T&E in general, or OT&E in particular, the RAN lacks the ability to effectively manage overall T&E, let alone OT&E, within the RAN.

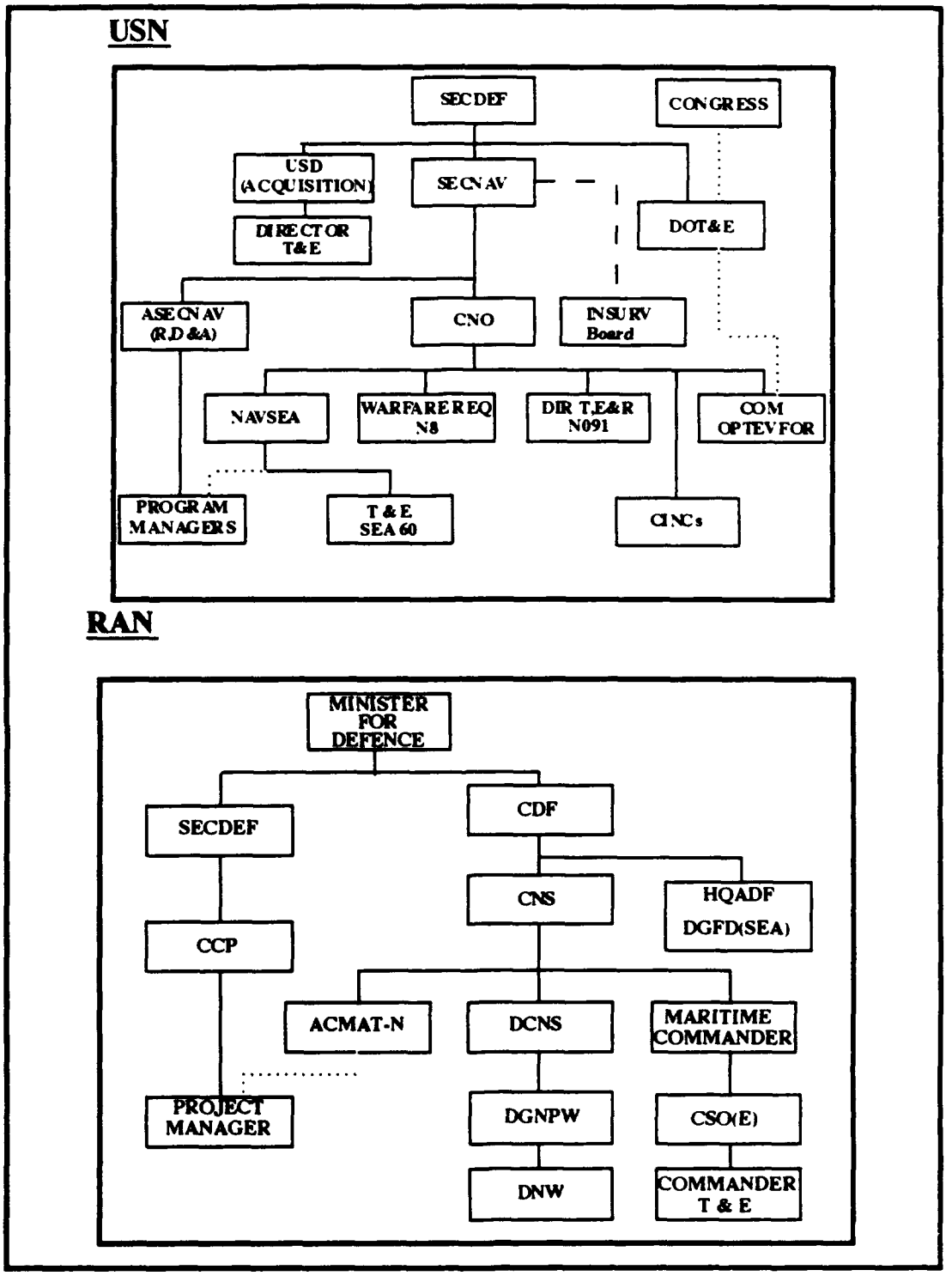

Figure 22: OT&E Organisation Comparison

E. OT&E POLICY

USN OT&E policy has its basis in statutes approved by Congress. The RAN has no such formal basis and its OT&E policy is embedded in the more general T&E policy. A number of OT&E policies of interest include:

1. OT&E Documentation

USN policy is refined in the DoD acquisition Directives 5000.1[Ref. 25] and 5000.2 [Ref. 24]. The essential T&E elements in these directives are further detailed in OPNAV Instruction 3960.10C [Ref. 11] and other subordinate instructions. USN OT&E documentation is comprehensive and provides clear, consistent and non-conflicting policies and guidance to OT&E participants. This concise documentation establishes the disciplined management approach to OT&E taken by the USN.

The RAN does not enjoy this sound basis of OT&E policy. Some general guidance to assist Project Directors in assessing the need for T&E in a project and to provide guidelines for its conduct is provided in the Capital Equipment Procurement Manual (CEPMAN 1)[Ref. 38]. The top level T&E policy document for the RAN is the Defence Instruction (Navy) on RAN Test and Evaluation Policy [Ref. 44], while ABR 1921[Ref. 41], contains T&E and acceptance policy applicable to ships building, undergoing modernisation, conversion or extended refit. These documents provide broad T&E policy only and, other than defining OT&E, provide little policy as to its conduct.

2. OT&E Requirements

In the USN system, the requirement to conduct OT&E on new major acquisitions is mandatory. Although the Sponsor initially develops the system thresholds, the level and extent of OT&E required is delineated in the TEMP and

approved prior to Milestone I. The appropriate level of OT&E is determined by COMOPTEVFOR in consultation with the Program Manager, with DOT&E oversight. This ensures that OT&E planning is conducted and approved early so the costs of OT&E can be included in project funds.

In the RAN, the decision to subject an acquisition to T&E is initially decided by the Sponsor and detailed in the Capability Proposal. The nature and extent of the T&E (no distinction is made in RAN policy between the various types of T&E) is decided by the Project Director in consultation with the Design Approval Authority and CTE. Any conflict over the requirement, nature and/or extent of the proposed T&E is resolved by DCNS and ACMAT-N for operational and design matters respectively.[Ref. 44:p. 2] The role of DCNS should now rest with DGFD(Sea) as the Sponsor. The determination of the OT&E required has traditionally not been achieved early enough in the life of a project, and so project funding has not included the provision for OT&E.

3. Independence of OT&E Authority

As OT&E is the final exam for an acquisition program, independence is necessary so that there is no question of impropriety. The USN requires its independent operational test activity to be separate and independent from the materiel-developing and procuring agency and the using agency. This ensures that the testing and reporting agency has nothing to gain or lose by whatever they say. As major acquisition decisions hinge on the results of OT&E within the USN, independence is necessary to ensure that the reports on which those decisions are based are not self serving.[Ref. 19]

Although major acquisition decisions within the RAN are less based on OT&E, the RAN also maintains the policy that OT&E is to be conducted by an authority independent of the development and production agencies. With the demise

of RANTAU and the transfer of OT&E responsibilities to CTE on the staff of the Maritime Commander, independence from the development and production agencies is achieved, but not from the end user as in the USN. The implications of this lack of independence are that the end user may have his own aims and objectives which may conflict with the total impartiality of OT&E reporting. The politics of requirements and funding could come into play, as the Maritime Commander establishes scheduling priorities for his resources, and OT&E may take a low priority behind operations and training. The Maritime Commander may also not wish to "stress" the system, in case he perceives that operational deficiencies so highlighted may be seen as having some reflection on his own organisation.

4. Contractor Involvement in OT&E

To ensure impartiality and credibility of testing, the USN prohibits persons employed by the contractor for the system being tested being involved in OT&E, unless contractors are planned to be involved when the system is deployed in combat.

The RAN requires that during OT&E, a system should be demonstrated "using normal Fleet Personnel", however, the policy documentation makes no statement regarding contractor personnel involvement in system operation or maintenance during OT&E. It has been RAN practice (e.g., in the DDG Modernisation Project) to have contractors onboard resolving technical problems during the SQT period, which is included as part of OT-3 in the RAN, thereby possibly causing test bias.

5. T&E Planning

Both the USN and RAN use the Test and Evaluation Master Plan (TEMP) as the single, executive, long range planning document for T&E in a project. Both Navies are in agreement that approval of the TEMP constitutes establishment of a

contract between the requirement-setter and the PM which is essential to formal and accountable program execution, and between the requirement-setter and the OT agency, upon which the OT agency will independently evaluate system operational effectiveness and suitability. The main differences between the two Navies are in the responsibility and level of approval, and in the timing of the TEMP.

a. TEMP Responsibility

Within the USN, the TEMP is drafted by the PM. COMOPTEVFOR drafts Part Four on OT&E and provides OT&E resource requirements for Part Five. The TEMP is then co-submitted by both the Program Manager and COMOPTEVFOR. It is reviewed by the Assistant Chief of Naval Operations (Surface Warfare), the Director, T&E and Technology Requirements, and the Assistant Secretary of the Navy (Research, Development and Acquisition). It is ultimately approved at the DoD level by the Director, OT&E and the Director, Test and Evaluation.

Within the RAN, the TEMP is the ultimate responsibility of the project sponsor [Ref. 44:p. 4]. However, during the period when there is a full time Project Office, TEMP coordination is normally carried out by the T&E Manager in the Project Office. CTE as the OT&E authority provides the OT&E input. The TEMP is endorsed by all affected organisations and is released jointly by the Deputy Chief of Naval Staff (DCNS), and the Assistant Chief of Naval Staff-Materiel (ACMAT-N), as the Developing Agency. If any issues remain unresolved at this level, the TEMP will be resolved by the Chief of Naval Staff (CNS). [Ref. 44:pp. 4-5] The authority for DCNS to release the TEMP was based on his role as Project Sponsor. With HQADF now assuming this role, the DCNS function in TEMP development is unclear.

In the USN, drafting the TEMP is the responsibility of the PM while the DoD heads of OT&E and DT&E authorities approve the TEMP. In contrast, in the RAN, the Sponsor has ultimate responsibility, although the TEMP is managed by the PM, and the TEMP is approved by the heads of the developing agency and the (former) Sponsor.

b. TEMP Timing

The TEMP is required in the at Milestone I- Concept Demonstration Approval within the USN, and is updated for each subsequent milestone and when significant program changes occur. The RAN requires the TEMP to be raised in draft form as early as practicable, but in actuality the TEMP for major projects is usually drafted after production approval (Milestone 3).

6. Combined DT&E and OT&E

"Combined testing" refers to a single test program conducted to support both DT&E and OT&E objectives. The advantages of combined testing is the shorter time required for testing, and cost savings by eliminating redundant activities. These need to be weighed against the limitations of the additional extensive coordination required and the less than optimum environment and coverage for OT&E that may occur. Early involvement of OT&E personnel during system development increases their familiarity with the system and permits identification of operational concerns early in the program.

The USN has a policy that combined DT&E and OT&E testing should be considered when there are time and cost savings [Ref. 24:p. 8-3]. However, this combined approach must not compromise either the developmental or operational test objectives. Also a final independent phase of operational testing and evaluation is required for beyond low rate initial production decisions [Ref. 24:p. 8-4]. The US has extensive experience with combined testing, some successful and some

unsuccessful, and they conclude that it is possible to have combined test teams involved throughout the testing process. The DT&E and OT&E teams can share mutually beneficial data, as long as the test program is carefully planned. However, evaluation and reporting activities must be conducted separately. [Ref. 18:pp. 17-1 - 17-4].

The conduct of combined DT&E, (PAT&E) and OT&E is not addressed in RAN T&E policy, however, it is implied as being almost a requirement. The T&E DI(N) [Ref. 44:p. 3] states that OT-3 and OT-4 will incorporate the requirements of PAT-6 and PAT-7 Inspection Tests and Trials as described in ABR 1921. It also states that OT-3 will be conducted during Ship Qualification Trials. The RANs "blurring" of the distinction between the types of T&E leads to DT&E and OT&E often being conducted over the same period, by the same test team. Although the RAN recognises, by definition, the difference in objectives and methodology between the types of T&E, no limitations or guidance as to the possible hazards of this combined testing approach are addressed.

7. Modeling and Simulation

The use of modeling and simulation can increase the efficiency of the T&E process, reduce the time and cost, provide otherwise unattainable and unmeasureable data, and provide more timely and valid results. The USN encourages the use of simulation and modeling to assist in projecting operational effectiveness and operational suitability prior to Milestone II - Development Approval, but limit the use of simulation and modeling in subsequent OT&E to that of supplementing OT&E test data [Ref. 15:p. 2-37].

The use of models and simulation in OT&E is not addressed by the RAN documentation, although modeling and simulation performed by the Maritime Systems Division of the Defence Science and Technology Organisation were used

by RANTAU to assist the evaluation of the upgraded combat and weapons systems in the Modernised DDGs.

With the increasing costs of weapons systems, decreasing budgets and the subsequent need for efficiency in the conduct of OT&E, simulation can be used during OT&E to extend test results, to improve the statistical sample, or to determine overlooked or directly unmeasured parameters. This is particularly relevant to the RAN who lack appropriate ranges and the financial resources for extensive test programs of expensive weapons. A policy directing the use of models and simulation in OT&E in the RAN is required.

8. Foreign Weapons Evaluation

The US DoD has a foreign weapons evaluation program which is designed to support the evaluation of a foreign nation's weapons system, equipment or technology in terms of its potential to meet a specific U.S. military requirement. The primary objective of the program is to reduce the costs of research and development, while leading to the acquisition of foreign equipment for U.S. use [Ref. 18:p. 21-1]. From the OT&E viewpoint, the USN 'try-before-buy policy' is still maintained, despite the early phases of OT being unable to be achieved. When procurement of a foreign weapon system is planned, the developing agency and COMOPTEVFOR may be directed to assess the adequacy of any previously conducted DT&E and OT&E and to provide recommendations on the need for additional T&E prior to procurement [Ref. 15:p. 2-34].

Despite the most recent Australian Government "White Paper" on Defence Policy [Ref. 6:p. 70] requiring the need to be able to determine the performance in the Australian environment of equipment of both overseas and local origin, no DoD or RAN T&E policy specifically addresses the evaluation of foreign systems. Prior to a major acquisition, project teams review possible contractors' proposals and

evaluate them against the user requirement. OT&E personnel may be part of these teams, however, there is no policy as to the OT&E authority's role in foreign weapons evaluation within the RAN.

9. OT&E Funding

OT&E is an expensive process and generally occurs late in the life of a project when money is usually tight. Within the USN, funding associated with T&E (including instrumentation, targets and simulations) are identified in the system acquisition cost estimates, acquisition plans and the TEMP [Ref. 18:p. 18-11]. The Program Manager plans, programs, budgets and funds the costs of all resources identified in the approved TEMP for all T&E through OT-III. Funds required to conduct OT&E are programmed and budgeted by OPTEVFOR and advised to the Program Manager. OT&E costs include test articles, expendables, targets, data collection and reduction and OPTEVFOR program related costs. The Program Manager does not fund fleet operating costs for T&E support, which includes fuel and aircraft, These costs for OT-II and III, and all costs for OT-IV, except procurement costs and OPTEVFOR costs, are funded by the Fleet CINCs.[Ref. 11:p. 21] The RAN employs a similar funding arrangement where OT&E is funded separately within a project and is estimated and bid for by CTE.[Ref. 44:p. 6]

The essential difference is that the USN develops the TEMP, and hence identify the resources required and their costs, earlier in a project's life than does the RAN, thus enabling the project to include these requirements in project funding.

10. Land Based Test Sites

A Land Based Test Site (LBTS) is a facility that duplicates, simulates or stimulates the employment of a system's planned operational installation and utilisation. Used primarily for the purpose of conducting DT&E, it is sometimes used to test system integration and overall performance. The USN often use LBTS

for the conduct of initial OT&E to gain an estimation of potential operational effectiveness and suitability, primarily to support Milestone IIIA (Low Rate Initial Production) decisions and not the more stringent Milestone IIIB (Full Rate Production).

RAN guidance for OT&E using land based test sites includes a statement that system centres and simulators will be employed for early stages of OT&E if available [Ref. 44:p. 4], and that OT-2 may be conducted at a land-based test site [Ref. 44:p. 3]. Although LBTS are being developed for both the ANZAC frigate and COLLINS submarine projects, OT-2 in support of production decisions will not be conducted. The use of these LBTS for later OT&E was not planned in the original project schedules, and so is subject to them being used on a non-interfering basis to the contractor.

The USN has demonstrated that early OT&E on LBTS can give an estimation of potential operational effectiveness and suitability, and hence identify potential operational problems early and minimising operational risk. Their use for OT&E during the ANZAC frigate and COLLINS submarine projects would appear to offer similar advantages to the RAN.

11. Ship OT&E

Both the USN and RAN recognise that ship acquisition projects will be treated differently to others in so far as protracted construction time usually precludes T&E of a prototype before the decision to proceed to production. Because the development and construction period for a major ship in the USN, normally precludes completion of initial OT&E on the lead ship prior to the production decision for follow-on ships, successive phases of OT&E are accomplished as soon as practicable to reduce risk and minimise the need for modification to follow-on units. Ship acquisition programs, therefore, usually have OT&E between Milestones

II and III, which consist of individual weapon systems testing and system integration at land based test sites.

With the construction of lower risk, proven overseas ships adapted to Australian requirements, the RAN assessed the degree of technical risk as low. OT&E between Milestones II and III in the RAN was, therefore, not considered necessary.

F. SHIP ACCEPTANCE

Both Navies have similar policies and procedures for acceptance of ships from contractors and then into service. However, only the USN states the purpose of ship acceptance which is "to ensure delivery to the Fleet of complete ships, free from both contractor and government responsible deficiencies" [Ref. 35:p. 1].

Each Navy uses similar terminology, but these have different meanings which can create confusion. A comparison of terms applicable to ship acceptance is given in Table 17.

1. Ship Acceptance Policy

Ship acceptance and Fleet Introduction within the USN has traditionally been based only on the successful completion of PAT&E and material inspections. However, with the treatment of ships as complete systems, as for the DDG-51, Fleet Introduction is now based also on OT&E results.

The RAN has also placed emphasis on PAT&E leading to Acceptance into Naval Service (AINS), although OT-3 has been included in the trials program leading to AINS. However, these trials conducted as OT-3, are really PAT&E / DT&E with minimal true OT&E.

TABLE 17: COMPARISON OF ACCEPTANCE TERMINOLOGY

USN Term	USN Definition	RAN Term	RAN Definition
Acceptance	The legal act of accepting custody of a new construction ship by the Navy upon delivery by a private shipbuilder.	**Delivery**	When the ship is contractually delivered from the contractor's ownership to the Government.
Delivery	The actual assumption of custody by the Navy incident to acceptance. The date of delivery from a private shipyard is also the date of acceptance.	**Preliminary Acceptance (PA)**	Determination that the ship has reached both material and support status sufficient to safely and effectively proceed with Navy trials. It is usually concurrent with Delivery.
Fleet Introduction	Approval by SECNAV that a ship class meets the operational effectiveness, operational suitability, safety and material standards for service use.	**Acceptance into Naval Service (AINS)**	Acceptance of the ship by CNS as a fully operational unit of the Fleet, based on operational performance and support levels obtained at that time.
		Operational Acceptance (OA)	Carried out only of first of class to supplement the AINS assessment using additional operational and support experience with the Fleet to refine the vessel and Naval Requirements.

2. Ship Acceptance Procedure

The procedure for USN ship acceptance and introduction to the Fleet as used for the DDG-51 program is outlined in Figure 23. A noteworthy aspect of the USN schedule is the exclusive OT-3 period, the results of which support a Fleet Introduction decision.

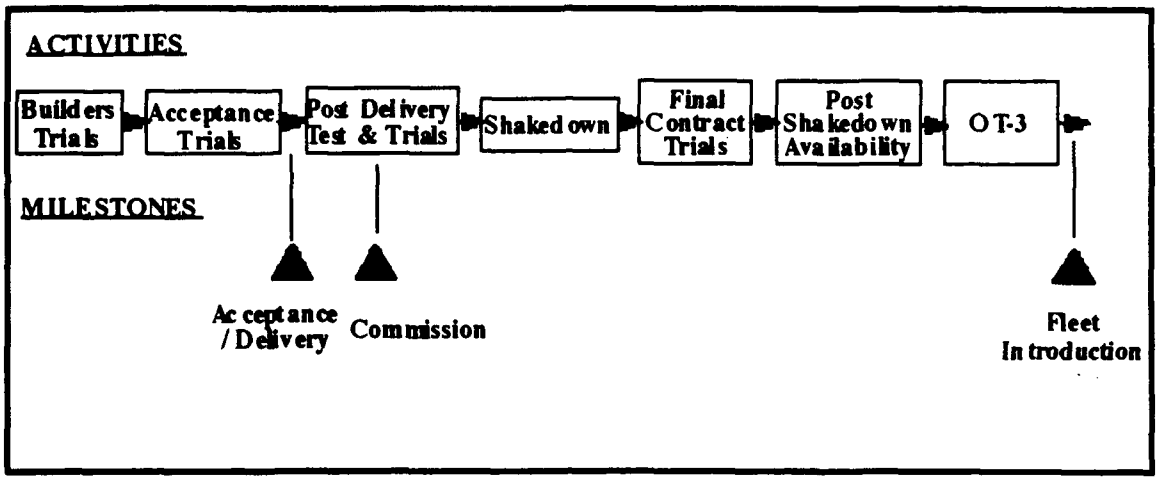

Figure 23: USN Ship Acceptance Schedule and Milestones

The Board of Inspection and Survey (INSURV) conducts Acceptance Trials and Final Contract Trials for each individual new ship to provide independent verification of readiness of ships for acceptance in the USN. Based upon its findings, the Board recommends acceptance or final settlement of the contract. The Board identifies material conditions which represent departures from the USN General Specifications and deficiencies that substantially reduce the ship's fitness for naval service or degrade its ability to perform its primary mission.[Ref. 34:p. 1] On successful trials completion, NAVSEA accepts the ship from the contractor.

For comparison, the RAN ship acceptance schedule, as used for the Australian Frigates and proposed for the ANZAC frigates, is outlined in Figure 24.

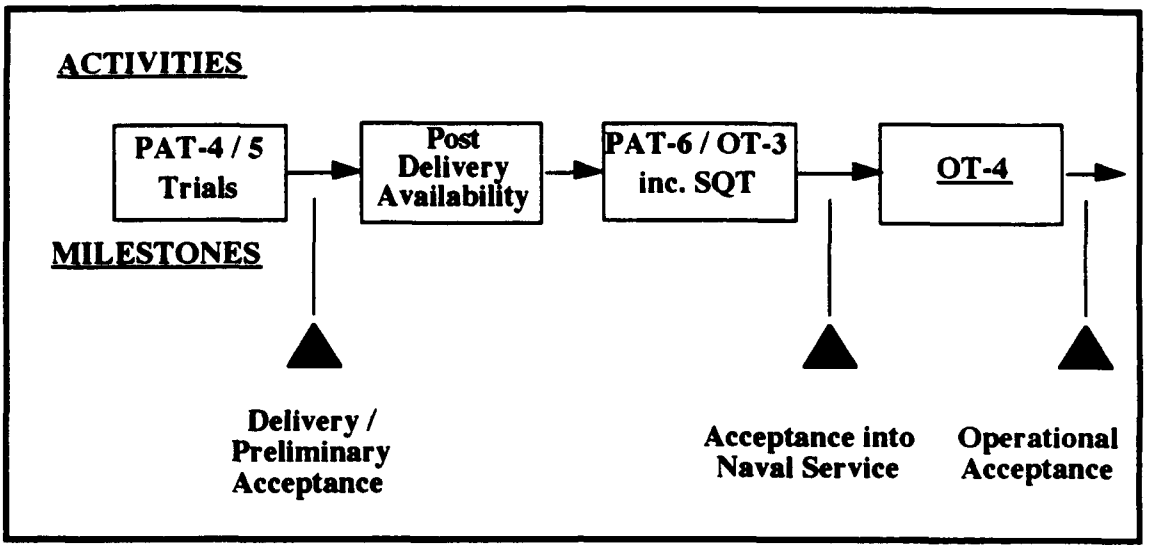

Figure 24: RAN Ship Acceptance Schedule and Milestones

Of note in this schedule is the combined PAT&E / OT&E period supporting an AINS decision, and the OT-4 phase leading to OA. OT-4 is not an exclusive T&E phase, but is integrated with the normal fleet operations of the ship. AINS is the most significant post delivery milestone as it represents acceptance of the ship into the RAN and that the project has met it's responsibilities.

In the RAN, Delivery (contractual acceptance) of the ship to the Government is a contractual matter and is managed by the Project Director. CTE's responsibility is to conduct the Acceptance Trials and report the results. An Acceptance Board (AB) is established to provide an assessment of the ship and submit recommendations upon which CNS can base his acceptance decision, however the AB is quite different from the INSURV Board. The AB is usually established for each new ship type and only for first of class. The President, Vice-President and Board members serve on the Board part time. The AB's sole function

is to advise CNS on acceptance matters, This is achieved by assessing the adequacy of the trials plans, examining the inspection and trials reports, attending trials where necessary and then providing an overall assessment of the adequacy of the ship against the user requirement. The Acceptance Board does not conduct tests, trials or inspections, and is essentially a board of review.

Acceptance into Naval Service is essentially the transfer/acceptance of the ship from the acquisition part of the Navy (ACMAT-N) to the inservice operations and support areas, as having met the user requirement. Post delivery trials leading to AINS includes the SQT period, with harbour and sea phases.

For the first of class, it will normally not be possible to trial and evaluate all aspects of the operational performance and maintainability prior to AINS. This OT-4 period is conducted following AINS and is compiled by RANTAU in consultation with the Naval and Maritime Headquarters Staff. It comprises a series of trials and evaluations to assess operational effectiveness and operational suitability. [Ref. 41:p. 15.14] Typically, the Follow-on T&E program will last from 12-24 months, depending on the class of ship. At the end of this period RANTAU compiles a report in consultation with Maritime Headquarters Staff. The AB assesses the results and provides the overview to ensure the program is comprehensive. This assessment serves to confirm or modify the assessment at AINS.

3. Ship Acceptance Summary

Both Navies now include OT&E in their post-delivery trials of the first of class to ensure that the ship is assessed operationally against the User Requirement. However the RAN OT-3 period is not true OT&E, but consists mostly of DT&E and PAT&E with some OT&E elements. The USN INSURV Board conducts acceptance trials on every ship but looks at materiel items only, which is different to the RAN AB, which is a board of specialists who review the trials and results of the first of

class. OT-3 within the RAN needs to be separated from the DT&E /PAT&E post delivery events, and should consist of true OT&E. This would enable the Acceptance Board to use its knowledge and experience in assessing the results of OT&E against the user requirement, instead of assuming a quality control function over what is essentially PAT&E testing.

G. OT&E PROCEDURES

This section discusses the procedures adopted by the two Navies in implementing OT&E policy.

1. User Requirement to OT&E Test Plan

To this concruence between OT&E test documentation and the user requirement, both Navies generate a series of documents through the acquisition process. Although the documents between Navies have different titles, they have similar functions. A comparison of the progression of documentation leading from the user requirement to the OT&E test plans is given in Table 18.

Both Navies can trace a requirement from the capability need through the refining requirements documentation to specific a objective in the TEMP, to the test plan and ultimately to the final OT&E report.

TABLE 18: COMPARISON OF REQUIREMENTS DOCUMENTATON

USN Document	Document Function	RAN Document
Mission Need Statement (MNS)	**Capability Need**	Defence Force Capability Proposal (DFCP)
Operational Requirements Document (ORD)	**Refined Requirement**	Required Operational Characteristics (ROC)
Top Level Requirement (TLR)	**Requirement Specifics**	Agreed Ships Characteristics (ASC)
Test and Evaluation Master Plan (TEMP)	**Overall T&E Plan**	Test and Evaluation Master Plan (TEMP)
OT&E Test Plan	**OT&E Plan**	Acceptance Management Plan (AMP)

2. Assessment of Operational Effectiveness

The RAN has found it difficult to define exactly what is required to assess operational effectiveness. The RANTAU guidance on the conduct of OT&E [Ref. 53] recognises that the user requirement is the bench mark for determining the degree to which a product is effective. Also that operational effectiveness is best assessed by a performance demonstration by normal operating personnel in the normal or given environment. But otherwise provides very little guidance on the assessment of operational effectiveness. Past techniques employed involve analyzing each COI and employing modified Ship Qualification Trial and Fleet Exercise Program techniques to evaluate them. Use has also been made of simulation, weapon analysis and exercise analysis. The lack of suitable range facilities has also limited the assessment of operational effectiveness.

The USN, by comparison, has a more effective method of assessing operational effectiveness. As do the RAN, the USN examines each COI and related operational effectiveness objective, and decides what needs to be known to enable each objective to be assessed [Ref. 15:p. 9-1]. They ensure that the appropriate environments, threats, etc. are included and that sufficient data will be generated to address the COI and objectives. They focus on achieving statistical relevance where possible, and making the tests as objective as possible. DOT&E works closely with the USN to help determine how many test assets are required to achieve a certain degree of confidence that the results are correct. A test may need to be repeated a number of times to gain statistical relevance. However, if this is not possible, or the direct proving of an ability is not possible (as in the surface warfare example), then the test needs to be designed so that what is observed in the test program is projected to be what would be observed in reality.[Ref. 19][Ref. 21] These situations require expertise and judgement, and compromise between the authorities involved, to make the tests as objective as possible.

3. Assessment of Operational Suitability

The principles of operational suitability are common between the USN and RAN, and similar aspects are assessed. Within the USN, COMOPTEVFOR reviews the Integrated Logistic Support Plan (ILSP) against the user requirement. Following this review, COMOPTEVFOR determines the suitability tests required based on expected reliability, degree of confidence, thresholds, etc. required to be achieved. These determine the scope and length of the assessment. Reliability, maintainability and availability (RM&A) data is collected and sent to the normal inservice analyst of RM&A data, the Naval Weapons Analysis Centre (NWAC) for analysis. Specialist analysts within OPTEVFOR design the tests and determine measures of suitability. They also evaluate and analyse the adequacy of logistic supportability.

However, OPTEVFOR also relies on operational personnel to use their experience and knowledge of the system to identify inadequate logistic support.

The assessment of operational suitability in the RAN has been controversial, particularly the assessment of supportability. Before 1987, the assessment of operational suitability, and ILS in particular, was rather subjective and often controversial. A new approach was taken in 1987 and has continued to be refined. The assessment of ILS is now conducted in two phases:

- ILS Structural Review
- ILS Operational Review

The ILS Plan is reviewed and discussions with the functional areas handling the support.conducted prior to operational testing. During the operational testing period, the ship's ILS related documentation and records are reviewed, maintainability demonstrations are performed and a supportability assessment is conducted. The RAN is currently developing a routine in-service RM&A data collection and analysis system, however, until that is operational, the data is collected and analysed on an 'as required' basis by the Trials Authority.

In summary, the principles of operational suitability assessment are common between the USN and RAN. Although assessments by the RAN have become less objective and more subjective over recent years, the assessment of RM&A is still in its infancy. Both Navies recognise the importance of data collection, however, the RAN needs experienced personnel to design tests and analyse results.

4. OT&E Coordination

The USN recognises the importance of coordination between authorities in the successful achievement of T&E. The USN T&E coordinator is responsible to the

Director, Test, Evaluation and Technology Requirements (N091). They are essentially the OPNAV Staff coordinator for Navy T&E, providing a primary contact point for all parties and setting up T&E briefings and meetings. Their responsibilities include the chairmanship of the Test and Evaluation Coordination Group (TECG) for each major program.[Ref. 37] TECGs are used for complex, multifaceted programs which require extensive T&E coordination. Membership of a TECG includes the Program Manager, the Sponsor, COMOPTEVFOR, a logistics coordinator and others as appropriate (such as a PREINSURV representative). TECG recommendations are considered for inclusion in the TEMP.[Ref. 11:p. 15] Some of the functions of a TECG are the early definition of terms, measures of effectiveness and how these are to be measured, and the criteria for acceptable or not acceptable. Of note is the formation of a TECG does not imply a joint test team approach. Each T&E agency remains fully and solely responsible for conducting and reporting the types and phases of T&E for which it is accountable.

In the RAN, a T&E Planning Group (TEPG) is formed prior to TEMP development under the leadership of the T&E manager for the project. Foundation members of the TEPG are the Project Director, Project Sponsor, the Design Approval Authority and RANTAU, with other parties seconded/called upon as required.[Ref. 44:p. 5] The TEPG analyses T&E requirements and estimates resources required to meet the requirements.

The function of these groups is similar, however, the USN TECG is led by the Director, Test, Evaluation and Technology Requirements (N091) under the CNO, whereas the RAN TEPG is led by each individual Project Director through this T&E manager. Despite their best intentions, Project Directors are essentially driven by cost and schedule considerations, not the overall T&E adequacy of their project. To be truly objective, each TEPG should be chaired by the authority responsible for ensuring the adequacy of the RAN's overall T&E program.

5. OT&E Reporting

Reports provide the OT&E authority's conclusions regarding a system's operational effectiveness and suitability, and his recommendations regarding the systems future, i.e., acceptance, further development, additional OT&E, etc. The USN system has three basic principles for OT&E reports:

- Impartial
- Complete and Thorough
- Sole Reporter

The conduct of OT&E must be impartial and not influenced by the program manager or contractors during testing and analysis. COMOPTEVFOR's conclusions are based on a complete and thorough analysis. A report covers a complete OT&E phase (e.g., OT-IIIA), relating the test results to the COIs and addressing the objectives stated in the TEMP. Quick-look and interim reports are usually sent only if the testing could not be completed or when directed by the CNO. Although the final report may be a surprise to other authorities. OT&E results and analysis are reported through one authority only. Comments from the Commanding Officer of the ship under test ship, for example, are sent only to COMOPTEVFOR. All operational test data is considered to be the owned by COMOPTEVFOR until the final report is signed.

Within the RAN, the OT&E Authority coordinates the issue of trials reports, however, they are issued on completion of each segment of OT&E e.g., o/c ASW phase of OT-3 etc. Quicklook reports are also routinely sent on completion of each week's testing. The ship under test also often provides a report, however, it is usually forwarded to their operational authority and the Project in addition to the Trials Authority. For the results of PAT&E, rapid feedback is necessary to ensure timely rectification of defects. However, OT&E results may indicate system

deficiencies against user requirements rather than equipment defects, so the results need to be fully analysed and the implications assessed before being reported to a wider audience. The RAN practice of OT&E reporting probably stems again from the lack of delineation between types of T&E and the combined PAT&E / OT&E nature of the RAN's OT-3 testing.

6. OT&E Personnel Selection and Training

OT&E is a specialised discipline, with its own philosophy and methodology, and so requires a specialist approach with knowledge and experience to make it effective.

a. Selection

The U.S. community involved with ship OT&E select and conduct limited training for their military personnel. Although there are no special selection requirements for detailing military personnel for service as Test Directors in OPTEVFOR, broad ship operations experience and combat system knowledge are preferred. For particular programs, OPTEVFOR make use of subject area experts, either resident or borrowed from a non-interested party. Military personnel required by DOT&E are selected by background and expertise, preferably war college graduates with joint experience.

No special selection criteria is involved for posting OT&E personnel within the RAN, although like the USN, broad ship operations experience and combat system knowledge are preferred. Very few personnel have had any T&E experience prior to joining the OT&E authority. Also currently the OT&E authority is viewed by some as not being career enhancing for warfare personnel.

b. Training

COMOPTEVFOR conducts a four day Operational Test Director's (OTD) overview course covering the major areas of OT&E. Further details of this course are included in Appendix A. They also run adhoc segment courses which provide acquaints or updates on OT&E subjects e.g., analysis, test plan development and threat updates. To assist their personnel in managing OT&E, OPTEVFOR publishes the OT&E Director's Guide which documents their philosophy and methodology. [Ref. 21] Other authorities involved with OT&E also send personnel to attend this course. Although DOT&E does not conduct courses for new staff, a one month handover is usually required.

The RAN has no training courses on OT&E, or on T&E in general. A number of officers have completed the USN Operational Test Directors Course in recent years which has improved the knowledge and understanding of OT&E within CTE's organisation considerably. These courses have been arranged on an ad-hoc basis through overseas visit submissions rather than as pre-requisite courses for particular billets. For guidance of trials personnel and other authorities, CTE has developed a number of Standard Operating Procedures addressing certain aspects of OT&E.

c. Career Path

Although some personnel may develop into OT&E specialists, no career path in OT&E is consciously provided in the USN, and no naval personnel currently serving in DOT&E have served previously in OPTEVFOR. Similarly in the RAN, no career path in T&E is provided.

To be effective, OT&E ideally requires current, experienced, knowledgable personnel with high professional credibility within their field of expertise. To achieve this, selection of suitable personnel, adequate training and

good guidance documentation is required, and preferably a career path where OT&E is seen as suitable career progression by such capable personnel.

H. OT&E IMPLEMENTATION

Recent ship projects illustrate how these policies and procedures are implemented. The USN DDG-51 program employs a new hull with a new, evolutionary combat system. Noteworthy aspects of DDG-51 OT&E included OT-II on both combat and propulsion systems LBTS to gain an early indication of potential operational effectiveness and suitability which supported the decision to approve the DDG-51 to go beyond Low Rate Initial Production. Another characteristic of the DDG-51 program was "Whole Ship" OT&E where the whole ship is viewed as an integrated warfare system, rather than as a platform for individual warfare systems. OT-3 was conducted in a dedicated period following CSSQT and Final Contract Trials (but before the workup) to support a Fleet Introduction decision. It consisted of fully assessed, free play multi-threat scenarios with the emphasis on operational realism.

The implementation of OT&E policy within the RAN is best demonstrated by reviewing examples of ship OT&E conducted to date, and that planned for ships due to enter service in the near future.

The three RAN DDGs underwent a major modernisation and refit over the period 1987-1991. The major modernisation occurred with the ships' combat system, command and control system, sensors and weapons, with the aim of increasing the 'supportability' of the systems rather than increasing the ships' capability. As a low operational risk project, the OT&E followed the established RAN policy, however, it was the first to actually implement an OT-4 period to more fully assess operational effectiveness and operational suitability leading to OA.

Two US FFG-7 class frigates, known as Australian Frigates (AF), are being built in Australia. The AF is a low operational risk project, except for the addition of the Mulloka sonar. The OT&E followed the established RAN policy, however, it failed to plan an OT-4 period to more fully assess operational effectiveness and operational suitability of the Mulloka sonar.

Australia and New Zealand are cooperating in the building of the ANZAC frigate. Essentially a MEKO 200 design incorporating a combination of European and US equipment, the design is classified as low risk, although modifications to the design were necessary to meet RAN requirements. Although only in the early stages, the planned OT&E for the ANZAC ship follows the established RAN policy, with the OT-3 period combined with the SQT, being conducted prior to AINS. The ship class has a higher operational risk than either the modernised DDG or the AF.

The RAN is building six boats, known as the Collins class, to the Swedish Kockums Type 471 design. They will be the first submarines to be constructed in Australia and will have a unique equipment fit. These submarines possibly have the highest operational risk of all current major RAN combatant projects. Consequently the increased need for OT&E has been recognised. The planned OT&E program demonstrates a departure from the usual RAN OT&E policy, and reflects a growing awareness of the need to separate DT and OT activities, and to include a dedicated OT-3 period after the usual SQT and ORE.

These examples of RAN implementation of ship OT&E policy illustrates a number of key issues. The operational risk of ship projects within the RAN is increasing, leading to a growing awareness for the increased need for ship OT&E.

Significant differences in OT&E implementation between the USN and RAN are, first, that the RAN does not generally conduct OT&E to support the production or purchase decision of ships. Second, the RAN has relied on the results of a

combined SQT and OT-3 period to provide a basis for AINS, whereas the USN conduct a "whole ship" dedicated OT-3 phase to support Fleet Introduction.

L SUMMARY

The USN and RAN have similar acquisition systems and similar fundamental definitions of T&E. However, the OT&E systems differ in a number of significant areas. Both Navies appreciate the importance of T&E in the acquisition process, however, the level of importance of T&E, and OT&E in particular, differs greatly. The USN recognises that without OT&E, it risks deploying systems which cannot adequately perform significant portions of their missions, thus degrading its deterrent/defensive capabilities and endangering the safety of military personnel who operate and maintain the systems. The importance of OT&E within the RAN is not specifically addressed in any T&E policy document. The USN places emphasis on OT&E leading to full scale production where the majority of a project's funding is spent. In contrast, the RAN system places a high priority on the post production phase.

The RAN has adapted the more detailed USN T&E definitions to suit its own requirements. During this process, the RAN has lost the distinction between the types of T&E and often confuses OT&E with PAT&E / DT&E. USN OT&E policy has its basis in statutes approved by Congress. The RAN has no such formal basis and its OT&E policy is embedded in the more general T&E policy.

The USN OT&E organisation is well structured with comprehensive responsibilities for each participant, and clearly delineated from the DT&E structure. Following a number of recent reorganisations, the RAN's OT&E structure is in disarray, with no clear policy maker for T&E in general, or OT&E in particular, lacks functional authorities with T&E knowledge to advise Project Directors, and its OT&E authority is buried in the in-service area of the Maritime Command.

Both Navies have similar policies and procedures for acceptance of ships from contractors and then into service. Each Navy uses similar terminology, but these have different meanings. OT&E results in the USN is now having a greater input on ship acceptance. Although the RAN has traditionally included OT&E in support of AINS, the nature of the testing has really been more DT&E / PAT&E rather than true OT&E.

The USN OT&E system has, by necessity, developed into a well organised, well documented and effective system. The RAN system, on the other hand, suffers from confusing T&E policy documentation, a weak OT&E organisation structure and a general lack of OT&E knowledge and appreciation. The determination of the OT&E required has traditionally not been achieved early enough in the life of a project, and so project funding has not included the provision for OT&E. However, OT&E awareness and knowledge within the RAN is growing as evidenced by the proposed Collins class post delivery trials.

The RAN OT&E system, although originally based on USN OT&E philosophy, now differs in the importance, interpretation, application and focus of OT&E As a result of organisation changes, it now lacks the ability to effectively manage overall T&E, let alone OT&E, within the RAN. To achieve efficient and effective trials and acceptance of the new higher risk combatants currently under construction, the RAN OT&E system needs to be revised to fully support the acquisition process.

VI. A MODEL FOR OT&E IN THE RAN

This chapter proposes a model for the OT&E system in the RAN. The OT&E principles derived from the USN system are used to develop a system to suit RAN requirements.

A. TEST & EVALUATION DEFINITIONS

The basis for the OT&E system are clear definitions of the types and phases of T&E. The RAN should continue to recognise the three types of T&E associated with ships. The current definitions listed in the CPO Manual [Ref. 38] should be amended to better suit the Australian Defence environment.

1. Development Test and Evaluation (DT&E)

The DT&E definition remains unchanged as follows:

DT&E is conducted to assist the engineering design and development process, and to verify attainment of technical performance specifications and objectives.

The proposed phases of DT&E are detailed in Table 19. The three phases

TABLE 19: PROPOSED PHASES OF DT&E

Current RAN Description	DT	Proposed RAN Description
Validation of design concept.	**DT-1**	Validation of design concept.
Proving design.	**DT-2**	Demonstration that design meets specifications.
Demonstration that production meets required technical characteristics.	**DT-3**	Demonstration that production meets required technical characteristics or establish standards for first of class. PAT&E is a form of DT-3.

are retained, however, the DT-2 definition is amended to clarify the meaning of "proving design", and the DT-3 phase now recognises that PAT&E is a form of DT&E.

2. Production Acceptance Test and Evaluation (PAT&E)

The definition of PAT&E is revised to recognise that it is conducted not only during the contract period, but also during subsequent RAN testing:

> *PAT&E is conducted on production items to ensure systems meet technical specifications and requirements, and is a type of DT&E.*

The proposed phases of PAT&E are listed in Table 20. Phases PAT-0 to PAT-5 remain unchanged. PAT-6 is amended to delete any connection with OT-3, as under the proposed model OT-3 will now be conducted separately. The PAT-7 phase is deleted as no PAT&E is conducted during the OT-4 phase of testing.

TABLE 20: PROPOSED PHASES OF PAT&E

Current RAN Description	PAT&E	Proposed RAN Description
Design and engineering development tests	**PAT-0**	Design and engineering development tests
Production and burn-in tests	**PAT-1**	Production and burn-in tests
Environmental qualification tests	**PAT-2**	Environmental qualification tests
System development tests	**PAT-3**	System development tests
Harbour testing	**PAT-4**	Harbour testing
Sea testing	**PAT-5**	Sea testing
Operational and Qualification Trials (conducted with OT-3)	**PAT-6**	Certification and Qualification Trials
Follow on Operational T&E (conducted with OT-4)	**PAT-7**	Nil.

3. Operational Test and Evaluation (OT&E)

The definition of OT&E is revised along USN lines, so that it more accurately describes the purpose and nature of OT&E:

> *OT&E is conducted to determine a system's operational effectiveness and operational suitability, identify system deficiencies and the need for potential modifications to meet established OT thresholds, and develop tactics. OT&E has three distinguishing characteristics:*
>
> - *It is conducted in an operationally representative environment.*
> - *It is conducted on production representative equipment using fleet personnel for operation and maintenance.*
> - *It is conducted against a threat-representative simulated enemy carrying out threat tactics per the latest threat assessment.*

The proposed phases of OT&E are described in Table 21. These amended definitions include reference to the acquisition milestones they support. The reference to OPEVAL in the OT-2 phase has been deleted, as the RAN uses the term OPEVAL as an abbreviation for an operational evaluation in any OT phase. The reference to a prototype in OT-2 has also been deleted as OT-2 may also be conducted in a LBTS, or on a sample system if the proposed purchase is "off the shelf". The OT-3 phase is revised to delete the Certification /Qualification Trials as they are now recognised as PAT&E. The definition of OT&E includes the use of normal fleet personnel so this wording has been deleted from the phase definitions. The OT-5 phase is amended to cover all in-service OT&E which could be conducted to assess new applications, new tactics, revised threat, etc. Reference to defect rectification is deleted also as it is a sub-phase of OT-4, and the assessments of modernisations and modifications are deleted as they would be new OT-2 or OT-3 phases.

TABLE 21: PROPOSED PHASES OF OT&E

Current RAN Description	OT	Proposed RAN Description
Operational assessment of the development proposal	**OT-1**	Operational assessment of the development proposal to support Full Scale Engineering Development approval.
Demonstration of achievement of program requirements for operational effectiveness and suitability of a prototype (**OPEVAL**) to support proceeding to full production	**OT-2**	Demonstration of achievement of program requirements for operational effectiveness and suitability to support a production or purchase decision.
Demonstration of achievement of program requirements for operational effectiveness and suitability on production of ship/aircraft/system, normally in independent operations using normal Fleet personnel. **Certification/Qualification** Trials include limited reliability, maintainability, availability and logistic supportability assessments.	**OT-3**	Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/ aircraft/system to support Acceptance into Naval Service. Includes limited reliability, maintainability, availability and logistic supportability assessments.
Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/ aircraft/system using normal Fleet personnel in a multi-force, multi-threat environment, Includes detailed reliability, maintainability, availability and logistic supportability assessments.	**OT-4**	Demonstration of achievement of program requirements for operational effectiveness and operational suitability on production of ship/ aircraft/system in a multi-force, multi-threat environment to support Operational Acceptance. Includes detailed reliability, maintainability, availability and logistic supportability assessments.
Follow-on OT for assessment after modernisations, new applications or defect rectifications after OT-4.	**OT-5**	In-service OT&E, which could include new applications, new tactics, revised threat, etc.

4. T&E Types in Total Ship Test Program

The Total Ship Test Program (TSTP) concept is now well established in RAN shipbuilding projects, although modified from the U.S. system. These refined T&E phases can be incorporated into an amended TSTP. However, instead of being grouped together as in the current TSTP, the DT&E and OT&E events are separate categories of testing. Because these separate DT&E, PAT&E and OT&E events are integrated within the TSTP, these trials are termed collectively as "Integrated Tests and Trials", which is an extension of the current RAN application of this term. The proposed categories of ITT are listed in Table 22.

TABLE 22: CATEGORIES OF ITT

ITT Part	ITT Category	T&E Type	Description
ITT Part 1	ITT-0 *	PAT-0	Design and engineering development tests
	ITT-1	PAT-1	Production and burn-in tests
	ITT-2 *	PAT-2	Environmental qualification tests
	ITT-3 *	PAT-3	System development tests
	ITT-4	PAT-4	Harbour testing
	ITT-5	PAT-5	Sea testing
ITT Part 2	ITT-6	DT-3 / PAT-6	Certification and Qualification Trials
	ITT-7 *	OT-3	Operational T&E
ITT Part 3	ITT-8 *	OT-4	Follow on Operational T&E

Note: * Only performed on first of class

The Certification and Qualification trials (ITT-6) are classified as DT&E for the first of class only, as standards of performance are established. For follow-on ships these trials are classed as PAT&E, as the standards established by the first of

class become the benchmark to be achieved by follow-on ships. ITT-0, ITT-2, ITT-3 and ITT-7 tests are performed only on the first of class. ITT-8 testing would only be performed once for a ship class, but may be conducted progressively on any ship of the class.

B. T&E IN THE ACQUISITION PROCESS

To ensure the progressive assessment of operational effectiveness and operational suitability during the acquisition process, OT&E is scheduled towards the end of each acquisition phase, usually after the DT phase. The proposed T&E schedule is shown in Figure 25. No change is suggested to the current relationship between OT&E phases and acquisition milestones, however, the figure separates DT&E/PAT&E from OT&E to clearly differentiate these different types of testing.

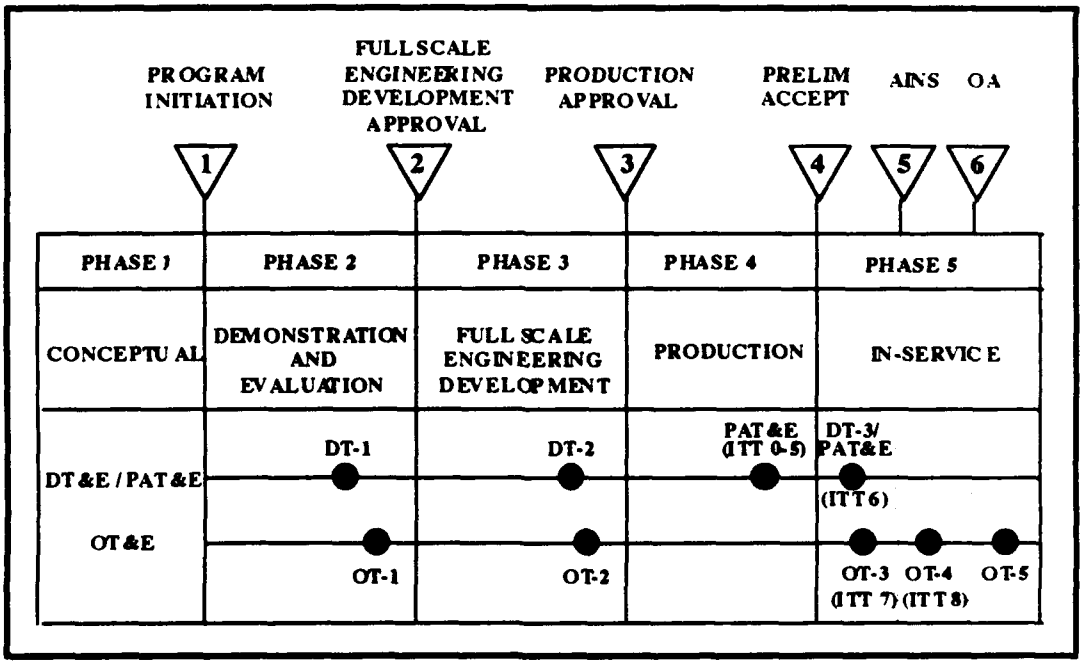

Figure 25: Proposed Test and Evaluation in the Acquisition Process

As the construction of proven overseas ship designs adapted to RAN requirements, does not require the conduct of OT-2 prior to a production or purchase decision, the first opportunity to evaluate potential operational effectiveness and operational suitability may be in a LBTS after the production decision has been made. To ensure consistency of terminology, this testing should not be termed OT-2 as it does not support a production or purchase decision. It should be classified as the first phase of OT-3.

C. RAN OT&E ORGANISATION

The objective of an OT&E organisation structure is to provide effective OT&E to support the acquisition process, and hence the combat effectiveness of the RAN. The proposed OT&E structure is shown in Figure 26. The effectiveness of OT&E

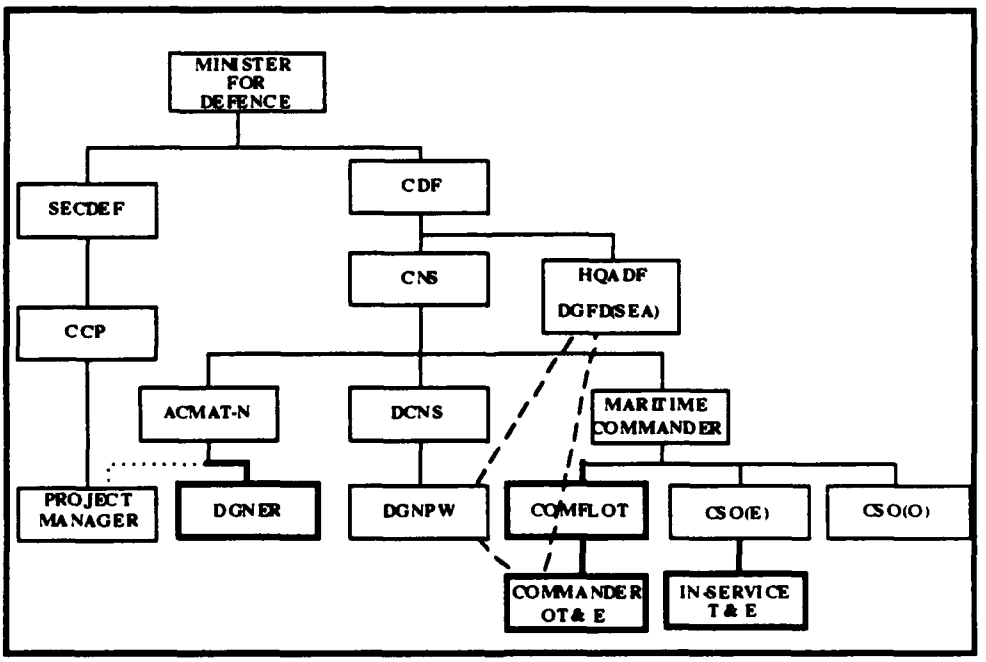

Figure 26: Proposed RAN OT&E Organisation

can be achieved by devoting appropriate resources of both personnel and funding, by considering the requirements of all functional areas concerned with OT&E, and by coordinating these different functions.

1. Policy Maker and Overseer

An authority is required to formulate OT&E policy, and to evaluate and oversee the OT&E process. OT&E policy should come from an operational, not technical, functional area. HQADF now contains the centralised force development and user requirements organisation. As OT&E is the feedback of the performance of the final product against the user requirement, then ideally, the head policy maker and overseer of OT&E should be within HQADF or DoD, along the lines of the U.S. system.

A shorter term, RAN-only, solution would be to include the overseer and policy maker function within the revised Director General Naval Policy and Warfare (DGNPW) organisation under DCNS. Although this area has recently been reduced, DGNPW still retains the responsibility for naval warfare information and expertise. The Director of Naval Warfare (DNW), under DGNPW, provides an information brokerage service to senior level management. He currently has a secondary function of providing naval warfare input to the Defence Capability Proposals developed by HQADF, and providing advice on naval warfare operations, equipment and personnel aspects. [Ref. 55:p. A-4] The responsibility of providing advice and input on OT&E matters, as part of the OT&E policy maker and overseer function for the RAN, is seen as a natural extension to these current responsibilities.

2. Sponsor

The Sponsor of major naval acquisitions is DGFD(Sea) within HQADF. Traditionally in the RAN, it has been the Sponsor's responsibility to initially determine the T&E requirements in an acquisition program and to detail those

requirements in the capability proposal. To be able to determine the appropriate nature and extent of OT&E required, the Sponsor needs access to OT&E knowledge and experience. A close relationship needs to be maintained by DGFD(Sea) with the OT&E policy maker and the OT&E authority (Note dotted line).

3. Developing Agency

The Materiel Division under ACMAT-N, performs the Developing Agency function within the RAN. Currently major combatant projects establish a T&E manager, with the larger ones also establishing a manager exclusively for post delivery trials. For example, the Australian Frigate Project has a Post Delivery Test and Trials manager, and the New Submarine Project has just established a Submarine Project Transition and AINS manager. However, ACMAT-N does not have a central T&E policy authority to advise these T&E managers. Although the Director of Naval Equipment Production (DNEP) has responsibility for providing specialist technical advice on technical/engineering activities, which includes trials and acceptance of equipment [Ref. 64], he specialises more in advice for contract management than for post delivery T&E.

To assist all RAN projects with T&E matters, an authority is required within the Materiel Division whose responsibilities would include assisting Project Directors in complying with policies, incorporating lessons learned from previous projects and reviewing the T&E aspects of projects at major milestones. Although primarily a DT&E policy authority, this office would also have an input into the OT&E process by reviewing the TEMP, and by advising projects how to prepare for OT&E. The Director General Naval Engineering Requirements (DGNER) is currently responsible for the design, development, acceptance into service and through life support of ships. This engineering policy directorate appears to be well suited to the DT&E policy and review function.

4. OT&E Tester & Evaluator

Ideally, the OT&E Tester & Evaluator should be independent and focus exclusively on OT&E. He should also have operational credibility and influence in operational matters relating to OT&E. The current OT&E Tester and Evaluator, Commander, Test and Evaluation (CTE), within the Maritime Command is independent from developing and production agencies, but is responsible to the end user of the system. This arrangement has advantages to CTE of access to knowledgeable and experienced fleet staff warfare officers and fleet planners for assistance in trials planning and assessment. However, there are possible disadvantages to this lack of independence from the end user. The Maritime Commander may have aims and objectives which could conflict with the total impartiality of OT&E reporting. As the Maritime Commander establishes scheduling priorities for his resources, priority given to OT&E is subject to the politics of requirements and funding. OT&E may take a low priority behind operations and training. The Maritime Commander may also not wish to "stress" the system during OT&E, in case he perceives that operational deficiencies so highlighted may be seen as having some reflection on his own organisation.

CTE is currently multifunctional, conducting DT&E and PAT&E in addition to OT&E. This results in a lack of differentiation within CTE's organisation between DT&E/PAT&E and OT&E. Also being placed under the inservice engineering area of the Maritime Command, he lacks visibility and influence within the warfare community and hence credibility in operational matters critical to OT&E. CTE's OT&E responsibilities are overshadowed by his DT&E/PAT&E duties.

To achieve the advantages of DT&E and OT&E separation, a revised organisation is proposed, similar to that outlined by the former RANTAU in

Reference 63. All CTE's current DT&E/PAT&E responsibilities, and those already the responsibility of CSO(E), would remain with an in-service trials team under CSO(E). This trials team, headed by an engineering branch officer, would be formed from the current CTE technical personnel, and could also conduct certifications, Light Off Examinations, and the technical aspects of Ship Qualification Trials. The team would provide technical assistance and advice to a separate OT&E trials team.

CTE's OT&E duties would be removed and managed by a separate group, Commander, OT&E (COT&E), working under an operational authority. There are two such authorities within the Maritime Command; the Chief Staff Officer (Operations) (CSO(O)) who is responsible for plans and operations, and Commodore Flotillas (COMFLOT) who is responsible for Fleet readiness. As OT&E is the assessment of operational effectiveness and suitability, COT&E should be responsible to COMFLOT. Headed by a Warfare branch officer, COT&E would manage the post delivery trials period for all ships from the MHQ perspective. He would still manage the SQT, which, although not true OT&E, still has some operational input which could not be met by the in-service trials team under CSO(E). He would be the OT&E authority with responsibilities to manage all RAN OT&E including OT-3,which is now only conducted on first of class.

5. OT&E Organisation Summary

This proposed reorganisation achieves the aim of DT&E/OT&E separation with some concessions necessary due to manpower constraints. Also, by including OT&E under COMFLOT and managed by a Warfare Officer, OT&E could achieve the visibility, credibility and influence necessary within the RAN.

D. RAN OT&E POLICY IMPLEMENTATION

1. OT&E Policy Documentation

RAN T&E documentation needs to be clear, concise and comprehensive so that is serves as a valid reference and guide for all personnel involved with T&E. To correct the current inconsistent and out of date documentation, a major rewrite, rather than just updating is required. This rewrite of T&E documentation could be the vehicle by which the T&E system within the RAN is overhauled. Before the documentation is revised, T&E definitions and terminology need to agreed within the RAN and DoD. Then the OT&E and DT&E organisations within the RAN need to be resolved, and the appropriate policies decided. This could be achieved by the development of a revised RAN T&E DI(N), followed by ABR 1921which would be firmly based on the T&E DI(N).

2. Independence of OT&E Agency

Given that the proposed COT&E is organisationally independent from the developing and production agencies, his procedural independence should also be achieved to ensure impartiality and validity of testing. When OT&E is conducted, it should not be influenced by the Project or DAA. No Project or DAA personnel should be present during testing. A final report only should be issued by the Maritime Commander, with no progress or interim report (unless the testing is unusually lengthy), to allow full analysis and evaluation of the test results. This applies to OT&E conduct and reporting only. As the SQT period is classified as PAT&E it should continue to be conducted with the cooperation and assistance of Project authorities. Similarly, to ensure test validity and impartiality, contractors should not be present during OT&E.

3. T&E Planning

The RAN has embraced the U.S. TEMP concept as the single executive document for the management of T&E for major acquisitions. Although required early in a project, recent TEMPs have not been raised until after project funding has been approved. TEMPS need to be approved earlier to enable inclusion of post delivery PAT&E/DT&E and OT-3 in the Project Budget, and OT-4 in MHQ budget. The authority for DCNS to release the TEMP was based on his role as Project Sponsor. With HQADF now assuming this role, the DCNS function in TEMP development is unclear. The TEMP review process should be reviewed as part of the proposed OT&E system.

A T&E Planning Group (TEPG) is currently formed prior to TEMP development under the leadership of the T&E manager for the project to analyse T&E requirements and estimate resources required. The TEPG is similar to the USN TECG with one significant difference. The USN TECG is led by the Director, Test, Evaluation and Technology Requirements (N091) under the CNO, whereas the RAN TEPG is led by each individual Project Director through this T&E manager. Despite their best intentions, Project Directors are essentially driven by cost and schedule considerations, not the overall T&E adequacy of their project. To be truly objective, each TEPG should be chaired by the authority responsible for ensuring the adequacy of the RAN's overall T&E program. The proposed RAN OT&E policy maker and overseer, DGNPW's organisation, may best be suited to the chairmanship of each TEPG.

4. Combined DT&E and OT&E

With the recognition of the differences between DT&E/PAT&E and OT&E the RAN can now appreciate the advantages and difficulties of combined DT&E/ PAT&E and OT&E. By classifying SQT as PAT&E, and conducting a separate OT-

3 period for first of class, the conduct of combined and/or concurrent DT&E/PAT&E and OT&E can be addressed on the requirements of each individual trial.

5. Foreign Weapons Evaluation

Despite the most recent Australian Government "White Paper" on Defence Policy [Ref. 6:p. 70] requiring the need to be able to determine the performance in the Australian environment of equipment of both overseas and local origin, no DoD or RAN T&E policy specifically addresses the evaluation of foreign systems. The proposed revision of the OT&E system, and consequent DT&E revision, would result in a more credible and useful organisation. Policies could then be developed regarding OT&E and DT&E in the evaluation of foreign weapons systems. The current process of evaluations of foreign weapons by adhoc Project Teams could be modified to include greater formal involvement by T&E authorities.

6. Land Based Test Sites

LBTS can be used to highlight problems of operational effectiveness and suitability early in system development. Although LBTS are part of both recent major RAN combatant projects, the conduct of OT&E in these sites is planned to be limited to a non-interference basis with system development and integration. OT&E needs to be conducted during a dedicated period in the LBTS following successful DT&E, to gain an estimate of the potential operational effectiveness and suitability of the system. Again, the need for early planning to include OT&E in schedules and funding is highlighted.

7. Whole Ship Testing

The current OT&E to support an Acceptance into Naval Service (AINS) decision (OT-3) is little more than an extended SQT period where DT&E/PAT&E is conducted with some operational assessment. It is not considered to be adequate to

assess the first of a new ship class against the user requirement. To assess the operational effectiveness and suitability of a ship against the user requirement with the degree of confidence required for the Acceptance Board to support an AINS decision, a dedicated, free play, scenario based, OT-3 period is required. The proposed Delivery to AINS trials schedule, which is based on that currently proposed for HMAS COLLINS is shown in Figure 27.

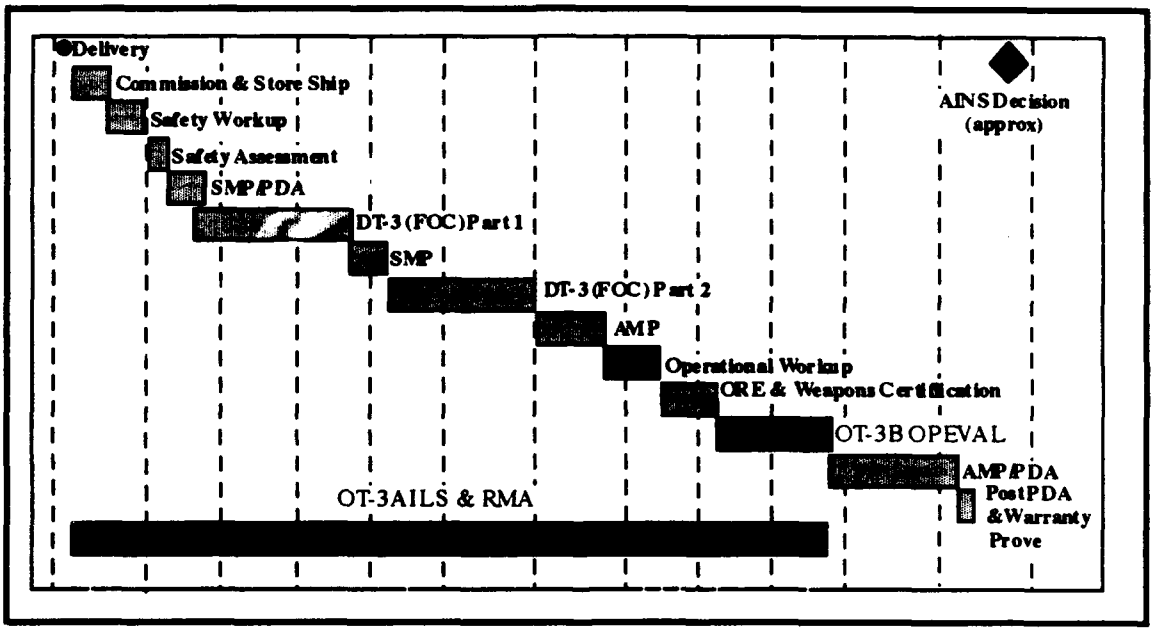

Figure 27: Proposed Delivery to AINS Trials Schedule

OT-3 should be conducted after the ship has completed the SQT and Operational Readiness Evaluation to ensure that the testing is conducted on a worked up and materially proven ship. To be effective the testing should be conducted of the overall ship as a complete weapons system. The recent USN innovation of "whole ship testing" provides a good example of the testing proposed. Whole ship testing includes engineering and technical problems combined with

combat system activity. It emphasises operational realism by testing the ship as though in war, and is designed to provide a realistic threat in an operational environment, and an element of surprise to provide realistic tests to support completion of the OT&E objectives and resolutions of the COIs.

The OT-4 period leading to Operational Acceptance (OA) proposed in this OT&E model is also based on the schedule currently proposed by CTE for HMAS COLLINS. An example of an AINS to OA trials schedule is shown in Figure 28.

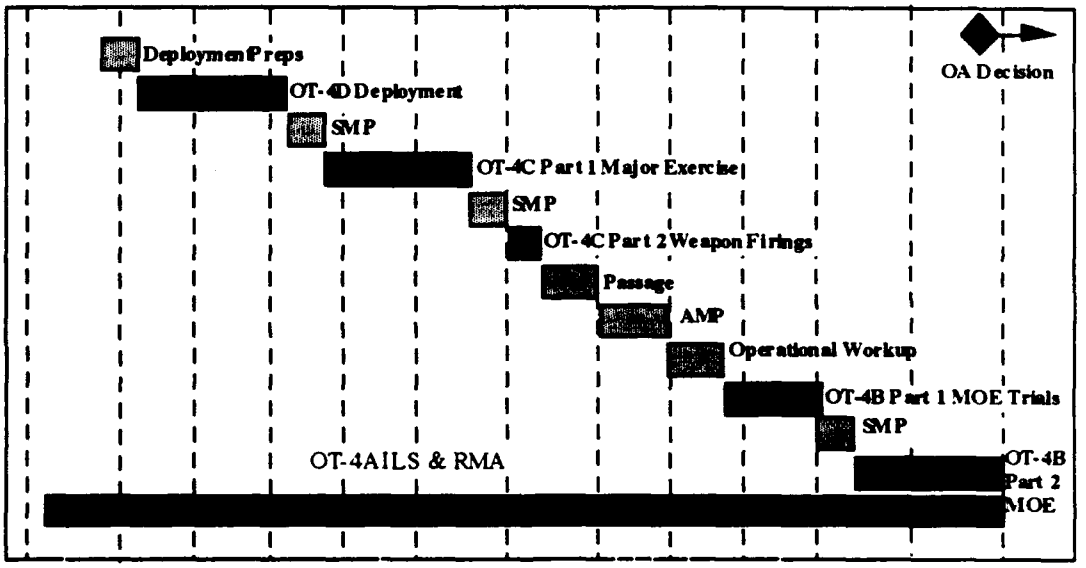

Figure 28: Proposed AINS to OA Trials Schedule

It includes a long term RM&A and ILS evaluation, further testing to achieve statistically significant results in critical areas and the assessment of the operational effectiveness and operational suitability of the ship in a major exercise and on deployment.

E. RAN SHIP ACCEPTANCE

The Acceptance Board, with its broader experience and knowledge than Trials Authority, is generally agreed within the RAN as being successful as a board of review of the planning and results of T&E for individual projects, and recommending PA and AINS. As an ad-hoc organisation consisting of various functional specialists brought together part time, however, the AB suffers from a number of problems.

The AB requires guidance as to its role and functions, T&E philosophy and the procedures of the acceptance process. Although the AB attempts to obtain sufficient guidance from the T&E documentation, it has found this documentation to be unclear and conflicting. To enable AB consistency and development, the Board needs an administrator, or permanent VP. RANTAU was the administrator and provided guidance to the Board, with CTE now assuming this role. However, the AB should be independent from the T&E authority as it assesses the trials planned and conducted by that authority.

With only DT&E/PAT&E and the minimal operational aspects of the previous OT-3 testing conducted by the RAN, the AB have tended to focus on materiel deficiencies. With a more comprehensive OT-3 period proposed to be conducted, the AB members could more effectively use their knowledge and experience in assessing the results of OT&E against the user requirement rather than on workmanship and materiel deficiencies.

The AB should be convened for the first of class only, providing the specialist expertise to interpret requirements and determine the level of acceptability required for AINS. The AB consists of Naval Officers drawn part-time from their normal jobs, and so the cost appears to be minimal. The AB, however, has a high opportunity cost, which is the value of the next best alternative on which the

members could be working instead of serving on the Board. Once the first of class is accepted the Board's task is complete. The interpretations and levels of acceptability established by the AB then guide the trials authority in recommending acceptance of each of the remaining ships.

F. RAN OT&E PROCEDURES

1. Assessment of Operational Effectiveness

With the proposed inclusion of a dedicated OT-3 period, the OT&E authority will need to develop tests for a free play, scenario based environment specifically designed to assess the COIs against the User Requirements. This could be achieved along USN lines where each COI and its related operational effectiveness objective is examined and the information needed to be known to enable each objective to be assessed is determined. The test design would have to take into consideration data collection methods and range considerations. The analysis of these tests may be different from the weapons analysis currently performed. Current weapons analysis focuses on individual weapon system performance, usually from "fire push" to "weapon destruct", whereas whole ship testing in a free play environment would require a broader analysis. An increased of use modeling & simulation may also be required to assess some systems in a cost effective manner. It is beyond the scope of this thesis to investigate these requirements, however, close liaison between the OT&E authority and the RAN's current analysis groups will be required to achieve valid testing and subsequent analysis.

2. Assessment of Operational Suitability

The current operational suitability areas now assessed are considered valid. These are listed in Table 23.

TABLE 23:SUITABILITY ISSUES FOR ASSESSMENT

Suitability Issues
Availability
Reliability
Maintainability
Safety
Human Factors
Interoperability
Compatibility
Integrated Logistic Support including:
Maintenance Planning
Supply Support
Support and Test Equipment
Technical Data and Documentation
Manpower and Personnel
Training and Training Devices
Facilities
Packaging, Handling, Storage and Transport
Computer Support
Configuration Control

The assessment of operational suitability, especially for the RAN's current combatant projects, should focus on interoperability and compatibility as these present the highest risks with the integration of proven equipment in a unique combination in a ship platform.

The assessment of ILS should continue to be conducted in two phases:

- ILS Structural Review. Conducted prior to operational testing, this review assesses if the ILS intended to provided will support the ILS policy of the Project.
- ILS Operational Review. During the operational testing period, the ship's ILS related documentation and records are reviewed, maintainability demonstrations are performed and a supportability assessment is conducted.

RM&A data is collected and analysed during OT-3 to give an indication of performance prior to AINS, and then continued for 12 months during the OT-4 phase. The data should continue to be collected and analysed on an "as required", vice continuous, basis by the Trials Authority until the RAN develops its routine in-service RM&A data collection and analysis system. The analysis of RM&A data is a specialist task, currently outside the experience of most uniformed personnel. To achieve significant and valid results, an RM&A analysis capability needs to be established, possibly within the Maritime Command's weapons assessing area.

3. OT&E Personnel, Training and Career Management

An effective OT&E system is dependent on knowledgable and experienced personnel. OT&E is a specialised discipline, with its own philosophy and methodology, however, very few personnel have had any T&E experience knowledge prior to joining the OT&E authority. This makes training important, but the RAN has no training courses on OT&E, or on T&E in general. A number of officers have completed the USN Operational Test Directors Course in recent years which has proved beneficial to the knowledge and understanding of OT&E within CTE. This course should be a pre-requisite for key billets within the OT&E authority until the RAN develops enough knowledge and expertise to develop its own course. Although the USN OTD course is only of a weeks' duration, it is understood that the USN is investigating a more comprehensive course. Other authorities also require training in OT&E. The OT&E authority needs to develop acquaint courses for other personnel with a need to understand OT&E e.g., Project T&E managers and capability requirements developers. Also to increase the awareness of OT&E in the RAN, the OT&E authority needs to deliver presentations regularly to Project Directors Courses, the ILS Management and Acquisition Course (ILSMAC), Defence management courses, and other appropriate acquisition courses.

Although some personnel may develop into OT&E specialists, no career path in OT&E is provided in the RAN. The warfare officer functional heads within the OT&E authority cannot currently aspire to command of the authority as that position is currently a Weapons Electrical Engineer's billet. The proposed change of the head of the OT&E authority to a Warfare Officer as COT&E should provide a career path within the authority. As the credibility of OT&E increases, the knowledge and experience gained by warfare officers in this area will be seen to be of more benefit in future warfare related positions, thus enabling a longer term career path. The proposed employment of COT&E under COMFLOT should also be more career enhancing for operations personnel than the current arrangement under CSO(Ξ).

The professionalism and knowledge of T&E personnel could be enhanced by membership in a related professional organisation. The International Test and Evaluation Association (ITEA) is one such professional organisation. Headquartered in the U.S. with a chapter in Australia, the association encourages the development and exchange of technical information in the field of test and evaluation. The corporate membership of a suitable professional organisation may be worthwhile to the RAN.

G. OT&E MODEL SUMMARY

The basis for this OT&E model are clear definitions of the types and phases of T&E. The current definitions are amended and phases of T&E are refined to better suit the Australian Defence environment. These refined T&E phases are incorporated into an amended TSTP, termed collectively as "Integrated Tests and Trials", which recognises the delineation between DT&E and OT&E. No change is suggested to the current relationship between OT&E phases and acquisition milestones.

The current OT&E organisation structure is modified to enable effective OT&E to support the acquisition process. It provides for authorities responsible for the management, policy making and oversight, and specification of OT&E. This proposed reorganisation closely achieves the aim of DT&E/OT&E separation.

The model proposes the inclusion of a dedicated OT-3 period in a free play, scenario based environment. The assessment of operational effectiveness is specifically designed to assess the COIs against the User Requirements and will require a different approach to analysis. The assessment of operational suitability focuses on interoperability and compatibility, and the assessment of ILS is achieved using current methods, but with improved RM&A analysis. This enhanced OT&E and minor modifications to the AB should provide CNS with a more comprehensive and thorough recommendation for AINS.

To be effective, OT&E ideally requires current, experienced, knowledgable personnel with high professional credibility within their field of expertise. To achieve this, the model includes adequate training, good guidance documentation, and a career path where OT&E is seen as career progression by capable personnel.

This OT&E model for the RAN uses principles derived from the USN system. By taking consideration of resource limitations, characteristics and culture of the RAN, it establishes an effective OT&E organisation which is important to the testing, evaluation and subsequent acceptance decision of the new combatants.

VII. CONCLUSIONS

A. GENERAL CONCLUSION

The USN OT&E system has, by necessity, developed into a well organised, well documented and effective, if complex, system. The RAN system, on the other hand, suffers from conflicting and confusing T&E policy documentation, a weak OT&E organisation structure and a general lack of OT&E knowledge and appreciation. The determination of OT&E required has traditionally not been achieved early enough in the life of a project, and so project funding has not included the provision for OT&E. The RAN OT&E system, although originally based on USN OT&E philosophy, now differs in the importance, interpretation, application and focus of OT&E. As a result of organisation changes, it now lacks the ability to effectively manage overall T&E, let alone OT&E, at a time when the operational risk of ship projects is increasing. To achieve efficient and effective trials and acceptance of the new higher risk warships currently under construction, the RAN OT&E system needs to be revised.

B. SPECIFIC CONCLUSIONS

1. OT&E in the Acquisition Process

Australia's Defence strategy has progressed from a position of dependence on allies, to a positive acceptance of both self-reliance and regional influence. To achieve its Defence goals, however, Australia devotes much less of its resources and places less priority on R&D than does the U.S. The need for local T&E is recognised by the Australian Government and DoD, for both indigenous and overseas systems, however, the importance of OT&E in particular, is not specifically addressed in any

Australian T&E policy document. This lack of recognition of the importance of OT&E is perhaps due to the RAN procuring low risk, complete ships in the past (e.g., FFG-7 class) with the wealth of USN DT&E and OT&E behind it.

U.S. OT&E is viewed as being more important as a basis for a decision to proceed beyond Low Rate Initial Production, than on the introduction into service of the final production item. This is because the "big bucks" of most Defence acquisitions are spent during the production phase. OT&E, however, has started to play an important role also in the assessment of first of class systems for introduction into the USN Fleet.

2. OT&E Organisation

The RAN and Australian DoD have reorganised over the past five years to create a more effective and efficient user requirements organisation, and to better accord with Program Management and Budgeting principles. However, as a result, the RAN has no T&E, or OT&E policy maker and overseer, no OT&E coordinator within Navy Office, and the RAN's OT&E authority is buried within the in-service engineering management area of the Maritime Command.

3. OT&E Policy

Where USN OT&E policy has its basis in the statutes approved by Congress, the RAN has no such formal basis and its OT&E policy is embedded in the more general T&E policy. The RAN has adapted the more detailed USN T&E definitions to suit its own requirements. During this process, however, the RAN lost the distinction between the types of T&E, and often confuses OT&E with PAT&E/ DT&E. Overall, RAN T&E documentation is not comprehensive, inconsistent and fails to provide adequate guidance.

The Commander, Test and Evaluation (CTE), on the staff of the Maritime Commander, is independent from the development and production agencies, but not

from the end user, as in the USN. The implications of this lack of independence is that the end user may have his own aims and objectives which conflict with the total impartiality of OT&E conduct and reporting.

Despite the most recent Australian Government "White Paper" on Defence Policy requiring the need to be able to determine the performance in the Australian environment of equipment of both overseas and local origin, no DoD or RAN T&E policy specifically addresses the evaluation of foreign systems.

Although used primarily for the purpose of conducting DT&E, the USN has demonstrated that early OT&E on Land Based Test Sites (LBTS) can give an estimation of potential operational effectiveness and suitability, and hence identify potential operational problems early and minimise operational risk. Although LBTS are being developed for both the ANZAC frigate and Collins submarine projects, the use of these LBTS for early OT-3 was not planned in the original project schedules, and so is now subject to them being used on a non-interfering basis to the contractor.

The RAN does not clearly differentiate between the types of T&E, which leads to DT&E and OT&E often being conducted over the same period, by the same test team. Although the RAN recognises, by definition, the difference in objectives and methodology between the types of T&E, no limitations or guidance as to the possible hazards of this combined testing approach are addressed.

4. Ship Acceptance

As an ad-hoc organisation consisting of various functional specialists brought together part time, the Acceptance Board (AB) suffers from a number of problems. It requires guidance as to its role and functions, T&E philosophy and the procedures of the acceptance process. Although the AB attempts to obtain sufficient guidance from the T&E documentation, it has found this documentation to be unclear and conflicting. With only DT&E/PAT&E and the minimal operational

aspects of the OT-3 testing conducted by the RAN, the AB has tended to focus on materiel deficiencies, rather than the performance of the first of class against the user requirement.

5. OT&E Procedures

The RAN recognises that the user requirement is the bench mark for determining the degree to which a system is effective, and also that operational effectiveness is best assessed by a performance demonstration by normal operating personnel in the normal or given environment. Assessing operational effectiveness has involved analyzing each Critical Operational Issue and then employing modified Ship Qualification Trial or Fleet Exercise Program techniques to evaluate them. The RAN has very little guidance on the assessment of operational effectiveness.

The principles of operational suitability assessment are common between the USN and RAN. Although assessments by the RAN have become more subjective over recent years, the assessment of RM&A is still in its infancy. The RAN requires experienced personnel to design suitability tests and analyse results.

The authority for the Deputy Chief of Naval Staff (DCNS) to release the Test and Evaluation Master Plan (TEMP) was based on his role as Project Sponsor. Now with HQADF assuming this role, the DCNS function in TEMP development is unclear. The TEMP approval process requires review.

The RAN Test and Evaluation Planning Group (TEPG) for each major project is chaired by each individual Project Director through his T&E manager. Despite their best intentions, Project Directors are essentially driven by cost and schedule considerations, not the overall T&E adequacy of their project. To be truly objective, each TEPG should be chaired by the authority responsible for ensuring the adequacy of the RAN's overall T&E program.

The early dissemination of OT&E results, before a full analysis is complete and the implications assessed, can lead to other authorities taking hasty action on incomplete information, and can prejudice the OT&E authority's final conclusions and recommendations. OT&E results should indicate system deficiencies against user requirements rather than equipment defects, so the results need to be fully analysed and the implications assessed before being reported to a wider audience.

Within the RAN, the current OT&E to support an AINS decision (OT-3) is little more than an extended SQT period where DT&E/PAT&E is conducted with some operational assessment. It is not considered to be adequate to assess the first of a new ship class against the user requirement.

To be effective, OT&E requires experienced and knowledgable personnel with high professional credibility within their field of expertise. To achieve this requires selection of suitable personnel, adequate training and good guidance documentation, and preferably a career path where serving in the OT&E Authority is seen as career progression by such capable personnel.

VIII. RECOMMENDATIONS

The OT&E model recommended for the RAN uses principles derived from the USN system. By taking consideration of resource limitations, and the characteristics and culture of the RAN, it establishes an effective OT&E organisation which is important to the testing, evaluation and subsequent acceptance decision of the new combatants.

A. GENERAL RECOMMENDATIONS

It is recommended that the proposed OT&E model be reviewed, evaluated and implemented in the RAN to achieve an effective OT&E system to support the introduction of operationally effective and operationally suitable new combatants into the RAN.

B. SPECIFIC RECOMMENDATIONS

1. OT&E Definitions

It is recommended that:

a. the current definitions and phases of ship T&E be amended to better suit the Australian Defence environment.

b. the current TSTP be revised to show DT&E and OT&E events as separate categories of testing, and these trials be termed collectively as Integrated Tests and Trials (ITT).

2. OT&E Documentation

It is recommended that:

a. the RAN T&E DI(N) and ABR 1921 be revised to achieve comprehensive and consistent T&E policy guidance.

3. OT&E in the Acquisition Process

It is recommended that:

a. OT&E be conducted, where possible, prior to the production or purchase decision in the acquisition process to minimise risk.

b. OT-3 be separated from the DT&E /PAT&E post delivery trials.

c. OT-3 be conducted as a dedicated, free play, scenario based period after the completion of SQT and ORE to ensure testing is conducted on a worked up and materially proven ship.

d. OT-3 of the overall ship be conducted as a complete weapons system.

4. OT&E Organisation

It is recommended that:

a. the appointment of a DoD OT&E policy maker and overseer within HQADF be investigated.

b. DGNPW be appointed as the OT&E policy maker and overseer within the RAN.

c. a close working relationship on T&E matters be required between DGFD(Sea), DGNPW and the OT&E authority.

d. DGNER be appointed as the Materiel Division T&E agency to assist Project Directors in complying with policies, incorporate lessons learned from previous projects, review the T&E aspects of projects at major milestones, and advise projects how to prepare for OT&E.

e. the current CTE organisation be disestablished.

f. an "In-service Trials" team be established under CSO(E) to conduct CTE's current DT&E/PAT&E responsibilities, and those already the responsibility of CSO(E).

g. Commander, OT&E (COT&E) be established as the RAN's OT&E authority under COMFLOT, to manage OT&E and the post delivery trials period for all ships from the MHQ perspective.

5. OT&E Policy

It is recommended that:

a. policy be developed to enable the performance in the Australian environment of foreign equipment to be evaluated efficiently, effectively and consistently.

b. the TEMP approval process be reviewed to ensure appropriate authorities are consulted and approve the TEMP.

c. the TEPG be chaired by DGNPW as the authority appointed to ensure the adequacy of the RAN's overall T&E program.

d. OT&E not be influenced by the Project or DAA, and that Project or DAA personnel not be present during testing.

e. contractors not be present during OT&E.

f. TEMPs for non-development projects be approved before production approval to enable inclusion of post delivery PAT&E/DT&E and OT-3 in the Project Budget, and OT-4 in MHQ budget.

g. OT&E be conducted during a dedicated period in the LBTS following successful DT&E, to gain an estimate of the potential operational effectiveness and suitability of the system.

6. Ship Acceptance

It is recommended that:

a. the Acceptance Board remain as a board of review.

b. the Acceptance Board be convened for the first of class only.

7. OT&E Procedures

It is recommended that:

a. The OT&E authority develop tests for a free play, scenario based environment specifically designed to assess the COIs against the user requirement.

b. analysis requirements of these tests be assessed, as they may be different from the weapons analysis currently performed.

c. experienced personnel assist in designing suitability tests and analysing results.

d. interoperability and compatibility be a major focus during the assessment of operational suitability, especially for the RAN's current combatant projects.

e. an improved RM&A analysis capability be established.

f. RM&A data continue to be collected and analysed on an 'as required' basis until the RAN develops its routine in-service RM&A data collection and analysis system

g. OT&E reports be made solely by the OT&E authority.

h. OT&E phase reports be issued only, with no progress or interim reports, to allow full analysis and evaluation of the test results.

i. the USN Operational Test Director type course be a prerequisite for key billets within the OT&E authority until the RAN develops enough knowledge and expertise to develop its own course.

j. the OT&E authority develop acquaint courses for other personnel with a need to understand OT&E.

k. the OT&E authority deliver presentations regularly to Project Directors Courses, the ILS Management and Acquisition Course (ILSMAC), Defence management courses, and other appropriate acquisition courses, so to increase the awareness of OT&E in the RAN.

l. a Warfare Officer be appointed to head the OT&E authority.

m. establishing corporate membership of a suitable professional T&E organisation be investigated.

APPENDIX A: USN OT&E COURSE SYLLABUS

The Commander, Operational Test and Evaluation Force (COMOPTEVFOR) conducts a four day Operational Test Directors (OTD) course designed to acquaint prospective Operational Test Directors and other interested personnel with the fundamentals of OT&E philosophy, terminology, policy and procedures. This course covers the following subject areas:

- Acquisition Program Overview
- Test and Evaluation Master Plan (TEMP)
- Operational Effectiveness Overview
- Operational Suitability Overview
- Logistic Supportability
- Fleet Research and Development T&E Support
- Operational Security
- Managing Money
- Weapons Systems Survivability
- Threat Support
- Test Planning
- Software Intensive Systems
- Modeling, Simulation and Analysis
- Conducting the Tests
- Lessons Learned
- Standards of Conduct
- Evaluation Reports
- Director, OT&E Perspectives
- Chief of Naval Operations Perspectives
- Program Manager Perspectives

- Relationship with General Accounting Office
- Test Resources
- Program Formulation

APPENDIX B: ACRONYM LIST

ABBREVIATION	FULL TITLE
A	
AAW	Antiair Warfare
AB	Acceptance Board (RAN)
ABR	Australian Book of Reference (RAN)
ACDEV-N	Assistant Chief of Naval Staff (Development)
ACMAT-N	Assistant Chief of Naval Staff (Materiel)
ADF	Australian Defence Force (RAN)
AF	Australian Frigate (RAN)
AINS	Acceptance into Naval Service (RAN)
AMP	Acceptance Management Plan (RAN)
ASC	Agreed Ship Characteristics (RAN)
ASUW	Antisurface Warfare
ASW	Antisubmarine Warfare
C	
CAP	Combat Air Patrol
CCP	Chief of Capital Procurement (RAN)
CEPMAN 1	Capital Equipment Procurement Manual (RAN)
CIWS	Close-in Weapons System
CNO	Chief of Naval Operations (USN)
CNS	Chief of Naval Staff (RAN)
COEA	Cost and Operational Effectiveness Analysis

COI	Critical Operational Issue
COMFLOT	Commodore Flotillas (RAN)
COMNAVSEA	Commander, Naval Sea Systems Command (USN)
COMOPTEVFOR	Commander, Operational Test and Evaluation Force (USN)
CPO	Capital Procurement Organisation (RAN)
CSE	Combat System Evaluation (RAN)
CSO(E)	Chief Staff Officer (Engineering) (RAN)
CSO(O)	Chief Staff Officer (Operations) (RAN)
CSSQT	Combat System Ship Qualification Trial (RAN)
CST	Combat System Trainer (RAN)
CTE	Commander Test and Evaluation (RAN)
D	
DAA	Design Approval Authority (RAN)
DCNS	Deputy Chief of Naval Staff (RAN)
DDG	Guided Missile Destroyer
DFCP	Defence Force Capability Proposal (RAN)
DGFD(SEA)	Director General Force Development (Sea) (RAN)
DGNPW	Director General Naval Policy and Warfare (RAN)
DGNW	Director General Naval Warfare (RAN)
DI(N)	Defence Instruction (Navy) (RAN)
DLSIE	Defence Logistics Studies Information Exchange (USN)
DNUR	Director of Naval User Requirements (RAN)
DNW	Director of Naval Warfare (RAN)

DoD	Department of Defence
DOT&E	Director of Operational Test and Evaluation (USN)
DSMC	Defence Systems Management College (USN)
DT&E	Development Test and Evaluation
E	
ECM	Electronic Countermeasures
ESM	Electronic Surveillance Measures
EW	Electronic Warfare
F	
FCT	Final Contract Trials (USN)
FFG	Guided Missile Frigate
FLEETEX	Fleet Exercise (USN)
FOT&E	Follow-on Operational Test and Evaluation (USN)
FSD	Full Scale Development (USN)
G	
GAO	General Accounting Office (USN)
GDP	Gross Domestic Product
H	
HATS	Harbour Acceptance Trials (RAN)
HMAS	Her Majesty's Australian Ship
HQADF	Headquarters, Australian Defence Force (RAN)
I	
ILS	Integrated Logistic Support
ILSP	Integrated Logistic Support Plan
IOT&E	Initial Operational Test and Evaluation (USN)

ITP	Integrated Test Package (RAN)
ITT	Inspections, Tests and Trials (RAN)
L	
LBTS	Land Based Test Site
LRIP	Low Rate Initial Production (USN)
M	
MHQ	Maritime Headquarters (RAN)
MNS	Mission Need Statement (USN)
MOE	Measures of Effectiveness
N	
NAVSEA	Naval Sea Systems Command (USN)
NCP	Naval Capability Proposal (RAN)
NWAC	Naval Weapons Analysis Centre (USN)
O	
OA	Operational Acceptance (RAN)
OCP	Operational Concept Paper (RAN)
OPD	Operational Performance Demonstration (RAN)
OPEVAL	Operational Evaluation
OPTEVFOR	Operational Test and Evaluation Force (USN)
ORD	Operational Requirements Document (USN)
ORE	Operational Readiness Evaluation (RAN)
OSD	Office of the Secretary of Defence (USN)
OTA	Operational Test and Evaluation Agency (USN)
OTD	Operational Test Director (USN)
OT&E	Operational Test and Evaluation

P

PA	Preliminary Acceptance (RAN)
PAT	Production Acceptance Test (RAN)
PAT&E	Production Acceptance Test and Evaluation
PD	Project Director (RAN)
PDA	Post Delivery Availability
PDT&T	Post Delivery Tests and Trials (RAN)
PM	Program Manager (USN)
PMBS	Program Management and Budgeting System (RAN)
PREINSURV	President, Board of Inspection and Survey (USN)
PSA	Post Shakedown Availability (USN)

R

R&D	Research and Development
RAN	Royal Australian Navy
RANTAU	RAN Trials and Assessing Unit (RAN)
REFTRA	Refresher Training (USN)
RM&A	Reliability, Maintainability and Availability
ROC	Required Operational Characteristics (RAN)

S

SATS	Sea Acceptance Trials (RAN)
SECDEF	Secretary of Defence
SQT	Ship Qualification Trial (RAN)
STW	Strike Warfare (USN)
SOE	Schedule of Events (USN)

SUPSHIPS	Supervisor of Shipbuilding (USN)
T	
T&E	Test and Evaluation
TECG	Test and Evaluation Coordination Group (USN)
TEMP	Test and Evaluation Master Plan
TEPG	Test and Evaluation Planning Group (RAN)
TLR	Top Level Requirement (USN)
TSTP	Total Ship Test Program
U	
USN	United States Navy
USS	United States Ship
W	
WSRL	Weapons Systems Research Laboratory (RAN)

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Commander Kenneth W. Joseph was born 16 April 1954 in Sydney, Australia. He joined the Royal Australian Naval College in 1971 where he completed his final two years of schooling. He then attended the University of New South Wales in 1973, graduating in 1976 with a Bachelor of Electrical Engineering Degree. This was followed by Naval Weapons Electrical Engineering application courses in the United Kingdom with the Royal Navy and sonar courses with the USN in 1977/78.

He served as the Assistant Weapons Electrical Engineering Officer of the modified DDG-2 class destroyer, HMAS PERTH from '78 -'80, where he managed the ASW and Gunnery systems. He then served in Navy Office, Canberra during 1981/82 on the staff of the then Director Naval Weapons Design, primarily concerned with the design and manufacture of the Australian indigenous sonar known as "MULLOKA". From 1982 - 85 he served as the Resident Naval Engineer at the sonar manufacturer's plant with progressing, contractual and technical responsibilities for the production of the MULLOKA system.

In 1985 he returned to sea as the Weapons Electrical Engineering Officer of HMAS PERTH which won awards for Gunnery and Missile system excellence, and the effectiveness of ASW, AIO and Communications systems.

In 1987 he was posted ashore as the Officer in Charge of the Trials Unit at the Royal Australian Navy Trials and Assessing Unit (RANTAU). His responsibilities included the trials and acceptance recommendations of all new, modified or overhauled ships, aircraft and other operational systems.

In 1991, he was posted to the Naval Postgraduate School in Monterey, California to pursue a Master of Science degree in Management.

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